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THE

# CURIOSITIES OF INDUSTRY

AND

# THE APPLIED SCIENCES.

BY

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AUTHOR OF "DAYS AT THE FACTORIES," &c.

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# ADVERTISEMENT.

THE late Mr. D'Israeli, in his celebrated 'Curiosities of Literature,' employed the term "*Curiosities*" to designate A MISCELLANY OF INTERESTING FACTS. The 'CURIOSITIES OF INDUSTRY,' although discursive in its character, forms a SUPPLEMENT TO THE CYCLOPÆDIA, having regard to the more precise industrial information which has preceded it, whether in connection with Science, Art, Geographical Knowledge, or Social Economy. It treats of INDUSTRY, under its NOVELTIES and RARITIES; its comparative CONDITION IN ALL COUNTRIES; its PROGRESS AT HOME, *especially during the present century;* its essential adaptation to CHEAPNESS OF PRODUCTION; and its extension under a system of UNIVERSAL INTERCOURSE. In the realms of SCIENCE, of the ARTS, of NATURAL HISTORY, of MANUFACTURES, of COMMERCE, of SOCIAL ECONOMY, there are abundant *new and curious* materials that may be presented both to the desultory reader and the diligent student, in a form at once inviting and instructive. The present time is more favourable to the formation of such a collection than any former period. The great Book of Nature and of Art has been fully opened to our view—and even "those who run may read" its wondrous pages.

The 'CURIOSITIES OF INDUSTRY,' although of general interest as a distinct work, forms a SUPPLEMENT to the 'NATIONAL CYCLOPÆDIA,' and to the 'CYCLOPÆDIA OF INDUSTRY OF ALL NATIONS.'

# CURIOSITIES OF INDUSTRY.

## GLASS AND ITS MANUFACTURE.

That most beautiful of all manufactured substances, *Glass*, is well fitted to commence this Industrial series. In few branches of industry have more remarkable changes taken place during the present century; in no other do we see exemplified more powerfully how much the mischief predominates over the benefit, in government interferences with manufactures; in no other may we observe more distinctly how the manufacturers of one country derive advantage by studying the works produced in other countries.

The "Curiosities" of Industry belong to all ages; but it is with especial reference to the last fifty years that many of them will be here noticed. We wish to show, by a rapid glance over the intervening period, in what way 1851 differs from 1801, in respect to any special department of industry. Have there been any new raw materials introduced; and if so, has the addition been made by improved legislation or by the exercise of inventive talent? Have there been improvements in the general routine of manufacture, either by the invention of new machines, or by the application of new manipulative processes? Have there been any new applications of the manufactured material to the every-day wants of society, either by rendering it cheap and abundant, or by employing it as a substitute for some other material? Has the progress of improvement been less or more rapid in our own country than among our neighbours? Such are the questions which, if even confined to the past fifty years of the present century, will yield us an abundance of "Curiosities," without necessitating any systematic description of the processes of manufacture: for them we may refer to the Cyclopædias to which the present work may be considered as a Supplement. If any of these subjects receive illustration, as doubtless they may, from the Great Industrial Congress of 1851—that epoch in the world's history—we shall not fail to avail ourselves of such valuable testimony; but the present papers have no especial relation to any temporary collection of works of industry: they chiefly relate to the advancements which have rendered such an Exhibition *possible*.

Let us now review the industry of the Glass-worker, under the aspects noticed above.

### Raw Materials—few recent Additions.

It would be a very fair assumption on the part of the reader, that as improvements have been made in so many departments of the glass-manufacture, advances would to an equal extent be made in the materials employed, either as to their variety or their quality. But this has not been the case. The truth is, that the substances so employed are very few and simple,

ıd do not admit of so many probable sources of improvement as the more ımerous and complex materials of many other branches of manufacture. lica, soda, potash, lime, oxide of lead—here we have nearly the sum total of e elements out of which glass is made. Bottle-glass has more lime than ıy other glass; plate-glass has more silica; flint-glass has more oxide of ad; and to these differences are probably mainly owing the characteristic ıalities of the several kinds of glass. The alumina, the manganese, the ide of iron, and the other substances which are employed in very small antity, are to remove colour, or to impart colour, or to modify in some way e qualities of the manufactured article; but they are not essential to its oduction. There would certainly be seen some modification, some addition; t a collection of glass-making ingredients at the present day presents a erably close resemblance to such as would have been presented half-a-cen-y ago. If we take, for instance, Mr. Apsley Pellatt's very interesting group glass materials at the Exhibition, we find the silex in the forms of washed d burnt sand, the alkali in the form of carbonate of potash, and the oxides lead and manganese; and three such series—silex, alkali, and oxides—uld similarly have been seen in an earlier collection. It is in the minor ails of each series that improvements have been and are now being sought. r instance, How can silex be obtained in greatest purity? is a question oortant to the glass-maker. Sand is, next to flint, the most familiar form which silex is presented to us. Sand from Lynn, from St. Helen's, from ghton Buzzard, and from many other places, is employed by glass-kers; Isle of Wight sand is almost pure silex; sand lately brought from nham Lake (the remarkable ice depôt) has been found equally pure; and d from Australia has been shown to be so peculiarly well fitted for the pro-tion of the finest glass, that it has been deemed commercially advan-eous to freight vessels with this substance alone. Flints and hard rocks, posed to be rich in siliceous matter, have been tried in a ground state; nó form of silica has been found suitable except that which is in sandy icles.

But even here we have a striking fact. An English vessel, free to carry any go which presents itself, brings common sea-sand a distance of sixteen ısand miles from Australia to England, in order that the glass-maker may e a fitting siliceous material for his manufacture; and we may be quite ain that this would not be done unless the manufacturers were willing to an adequate price for this humble import.

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been too busy during the last half-century to be left unnoticed. Rarely has there been an example of fiscal legislation on which opinions have coincided so completely as in respect to the pernicious effects of the glass duties; and rarely have predictions concerning the advantages of a reform been more fully realized. The able author of the Treatise on the Glass Manufacture in *Lardner's Cyclopædia*, writing just twenty years ago, said, "Whenever this measure (the removal of the glass duties) shall be accomplished, it can hardly fail to induce such an extension of the manufacture as will prove generally beneficial to the community. The abolition of these duties would be accompanied by the still further advantage of removing all those vexatious regulations and restrictions under which the manufacture is now carried on, and which will cease, as a matter of course, when the article is no longer an object of revenue. It is principally owing to these restrictions that so much foreign glass is now brought into this country in the face of what may be considered an amply protecting duty. Foreign manufacturers are allowed to make any and every article out of that quality of glass which will most cheaply and advantageously answer the end; while our own artists are forbidden to form certain objects, except with more costly materials, which pay the higher rates of duty. Nor is this restriction only commercially wrong, since it forms matter of just complaint on the part of chemists that they are unable to procure utensils fitted for effecting many of the nicer operations connected with their science; because the due protection of the revenue is thought to require that such utensils shall be formed out of that quality of glass alone which, apart from all considerations of price, is otherwise, from its properties, really unfitted for the purpose. Relaxations are indeed sometimes made on this head in particular cases by the Commissioners of Excise; but the trouble necessarily attending applications to a public board is greater than can be compensated by the trifling money advantage that can result in each case to the manufacturer; and the interests of science are, consequently, made to suffer."

The peculiar mode in which this strangely short-sighted legislation worked out its pernicious results will be noticed presently; but one of the most obvious of the results themselves was shown in the Excise returns of duty. While foreign countries were gradually improving their manufacture, ours was stagnating; and the duty furnished a sensitive barometer to mark this difference. The facts adduced by Mr. Porter ('Progress of the Nation') are really astonishing as illustrative of this point. In 1801, with a population of sixteen millions, the quantity of glass used (as shown by the Excise duty) was 325,529 cwts.; and in 1833, with a population of twenty-five millions, the quantity had only increased to 363,468 cwts. Between 1827 and 1845 the average price of the glass articles in most common use fell about 25 per cent.; but no thanks to the Excise for this: it arose from economical and improved modes of working. Science, commerce, manufacturing art, domestic comfort, architectural beauty—all were benefited by the happy revolution of the month of September, 1845, when the glass-makers' premises were relieved from the burden of the Exciseman's visits.

It would be hardly credible, were there not abundant evidence to testify it, how enormous was the mischief brought about by the late laws. The Report of the Commissioners of Excise Inquiry, in 1835, is full of instruction on this point; and we cannot do better than select a few items as illustrations.

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## Glass Duties—their Effects on Science and Art.

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scientific purposes. With Messrs. Chance, especially, he made experiments which led to the production of a superior kind of glass; but at the eleventh hour the Supervisor of Excise stepped in, and forbade all further progress, as the novelty would interfere with the technical ascertainment of the amount of duty; in fact, it was a matter simply of *thickness*, for the optician required glass thicker than the excise would permit. Mr. Dollond, then, with the aid of a friend, fitted up a small furnace, expressly and solely with a view to make experiments on a small scale; but this again was frustrated by a cold negative from the Excise authorities. "I do not wish," says Mr. Dollond, "to escape from paying duties or any charges; all I wish for is, to be allowed to make my experiments free from interference, or what are called established rules, or systems laid down to prevent roguery. In France and Switzerland such glass as I require is made and sold at a considerable price; and those large telescopes, which are at present so much talked of, are made with that glass. I am willing to buy it at almost any price; but, as it requires extreme care in the manufacture, it cannot always be procured. It would, therefore, be a great advantage if it could be manufactured at home."

Mr. Arthur Aikin, who was at that time the Secretary to the Society of Arts, gave abundant evidence tending to the same point. He clearly elucidated these three questions—why will not ordinary flint-glass suffice for optical purposes? how could it be made fitted for that object? and why may it *not* be so made fitted? In the first place, all flint-glass contains oxide of lead, which, from its great specific gravity, will not mix intimately and equally with the other ingredients; and the result is, that the refraction of the rays of light will be greater at one part of the mass than in another; consequently, such glass is unsuitable for delicate optical purposes. As, however, the glass may be ground to powder, and intimately mixed so as to bring about homogeneity throughout the mass, the distortion may be removed; and this may be still further realised by three or four grindings and meltings. But (and here was the blot which showed the defects of the system) the Excise claimed a new duty on the glass *every time it was remelted;* and unless the maker were willing to submit to this exaction, his improving process became null and void. Mr. Aikin stated that the glass used for optical purposes in France, Germany, and Switzerland was better than that made in England, and could be sold at a cheaper price; a state of things which he could only attribute to the Excise regulations. The duplication of the duty on the duplication of the melting has been adverted to above; and the obstacles to experimental research were equally formidable. "Soon after my appointment as Secretary to the Society of Arts," says Mr. Aikin, "I built a small furnace capable of making, perhaps, six or eight pounds of glass at a time, for the purpose of investigating the action of some of the causes that affect the quality of optical glass. On mentioning the circumstance to the late Mr. Carr, then solicitor to the Excise, and with whom I was personally acquainted, I received such an answer as determined me to give up my intention."

This same difficulty of obtaining the permission of the Excise to make any sort of experiments, lay at the root of multiplied evils and inconveniences connected with the manufacture. Glass-stainers and painters have long known that the old glass—independent of its rich colours—was better fitted than modern glass for the exercise of this beautiful art; they think that the old glass was harder and less fusible than the modern, and thus better able to bear repeated firings in the enamel-kilns; but any attempt made by them to carry out systematic experiments on the subject, with a view to determine the exact

cause of the difference, was frustrated by the Excise. Among the almost ludicrous results which followed from these obstructions, was the scientific reputation acquired by the humble Florence-oil flasks. It appears that, under the late laws, no green glass bottles were allowed to be made under the size denominated 'six-ounce;' it appears also that flint-glass, of which alone small bottles were permitted to be made, is, by virtue of the oxide of lead used as one ingredient, unfitted to resist some of the strong acids prepared by the chemists; and the chemists were thence driven to the use of the flasks in which Florence oil is imported, the glass of such flasks containing no lead.*

Another aspect which the subject presented was this—that a manufacturer, even if he obtained permission of the Excise to make experiments, could not do so without divulging the secret of any new invention he might have in his thoughts, were the invention patented or not.

Mr. Apsley Pellatt stated to the Commissioners that a very large lens could not be made at all in England, even of the same quality as smaller lenses; for the Excise allowed melted glass to be laded out into *cold* moulds only; whereas a large mass, for a lens of considerable size, could not be properly cast unless the mould were heated. The same manufacturer gave a curious illustration of the effects of the law in respect to barometer and thermometer tubes. The Excise required that *all* articles should be passed through the lear, or annealing oven; but it was found that the interior of these delicate tubes became smoked, and consequently unfitted for their purpose, by such an ordeal; and the English manufacturers had either to abandon the manufacture altogether, or to get the officers to connive at an arrangement whereby the duty might be paid without subjecting the tubes to the injurious process. There was also assigned a reason why—let the manufacturers and the glass-stainers be ever so skilful—they were not permitted to produce coloured glass so good as was obviously within the scope of their ability; the red and amber tints require that the glass-pot should be opened frequently, that the maker may test the progress; but under the Excise regulations a glass-pot could be opened only at certain intervals.

## Glass Duties—their Commercial Effects.

The scientific and artistic results of Excise restriction were, as above noticed, observable chiefly in the quality of optical glass, and the quality and colour of stained glass. The commercial results were very varied, and some of them strange enough. The *lear*, or annealing oven, in which flint-glass is annealed after making, has a window, and a wire within the window, concerning which the Excise were very rigorous; for the duty was charged on the whole contents of the lear, whether injured or not. Mr. Pellatt told the Commissioners that on one occasion one of the Excise officers, in a frolic, "threw a piece of glass at another, which broke the window of the lear. The supervisor observing it a few minutes afterwards, and taking out part of the glass and pushing back the wire, pronounced the lear to be insecure, and reported accordingly. A prosecution was instituted. After incurring about £60 law expense, the crown solicitor dropped the case, finding that his own witnesses would afford him no chance of success. As the crown paid no costs, we had to defray the whole expense of that prosecution."

The impossibility of collecting the flint-glass duty in a fair and equitable manner was made apparent in many ways. Mr. Powell, a Bristol manufacturer, said to the Commissioners, "I do not see what legislative protection

The battle between the Excise and the manufacturers was often a strange one. A drawback of 6*s*. 6*d*. per square foot (afterwards lessened to 2*s*. 9*d*.) was allowed on plate-glass when exported; and two manufacturers, taking advantage of this, made plate-glass so thin that, when exported and allowed the drawback, they gained largely by it. The Excise then made complicated laws—that the duty should be by weight; that the drawback should be by the foot; that plate-glass should not be exported if less than one-eighth of an inch thick; and that (to prevent crown-glass from having the drawback privileges of plate-glass) no crown-glass should be made thicker than one-ninth of an inch. Thus was the trade hampered for many years by laws rendered necessary (or alleged to be necessary) by the dishonesty of two persons: a pretty clear proof that the whole system rested on an unsound basis. Then again, in order that plate-glass might not interfere with the levying of the duty on flint-glass, it was enacted that no plate-glass should be made above a certain thickness; this restriction prevented an eminent manufacturing firm from carrying out a contract for supplying a very large lens for one of the northern lighthouses. When the reader is told that one kind of glass paid a duty of 7*s*. per cwt., while another paid 98*s*., and that three other kinds occupied three intermediate stages, he will see how much inducement manufacturers had to substitute one kind for another, and how much technical struggling would arise between them and the executive.

The year 1845, however, arrived, and with it the removal of the Excise duty on glass. Then, and then only, did the English manufacturer begin to feel himself a free agent, in a position to make experiments tending to the advance of his manufacture. There is thus a curious feature in respect to the half-century's progress; more has been effected in the last five years of the period than in the preceding forty-five years. It has shown itself in respect to plate-glass, to sheet-glass, to flint-glass,—indeed to nearly every department of the art. Let us take Osler's 'Crystal fountain,' for instance—a fountain that will presently be known to persons from almost every corner of the world as a distinguished ornament to the Palace of Industry. This fountain is certainly one of the most ambitious specimens which the art has yet put forth; and the result shows that the ambition has not "o'er-leap'd itself," for there are certainly few productions in the Exhibition more honourable to English art. The glassy structure is 27 feet in height, and weighs about four tons—nearly 9000 lbs. There must of course be numerous pieces of metal used to support the structure; but these have been so skilfully overlaid with richly-cut glass, that they are virtually hidden, and their opacity detracts little or nothing from the brilliancy of the whole structure.

Plate-glass has fully kept pace with flint-glass in the march of improvement.

Mr. Blake, manager of the Thames Plate-Glass Works, and Mr. Bessemer, have patented inventions for extensive improvements in the manufacture; and improvements of a minor kind have been introduced by other inventors. The result may, to some extent, be seen at the Great Exhibition; we there see plates of glass which have been so coloured as to imitate polished woods and marbles; we see in McLean's looking-glass the largest specimen of a brilliantly-framed glass ever executed in this country; but the quiet and modest unframed glass, at the west extremity of the nave, has the reputation of being the largest and the finest known specimen of British plate-glass: it measures nearly 19 feet by 10.

## Revived Taste: Stained and Coloured Glass.

Among the agencies which have tended to the increased employment of glass in artistic works must undoubtedly be included the partial revival of mediæval taste in ecclesiastical decorations. In the seventeenth century stained-glass windows in churches met with much fierce opposition; while in the eighteenth they encountered neglect and indifference; and as there was thus little or no demand, the skill which could furnish a supply became nearly lost. Hence it has arisen that the artists in this department, at the present day, have had to study anew the principles and practice of their art. It has been remarked by competent critics, that, in the specimens which exemplify the progress of the artists, the defects as well as the beauties of the mediæval productions are attempted to be imitated, as if the revived art had not yet strength to walk alone. In the Great Exhibition, the quaint and stiff drawing of many of the figures in the stained-glass specimens is apparent enough; yet it is impossible not to observe that great beauty of colouring is displayed, and it is under this aspect alone that we allude to the subject here. In the Mediæval Court the stained glass has too little light behind it to display the colours well; but in the gallery, on the northern side of the foreign nave, a particularly happy arrangement has been adopted for the varied examples of stained-glass, British and foreign, whereby the colours and general execution are developed with surprising distinctness. The fine window, too, in the centre of the foreign nave, well exhibits the skill in colouring and in the distribution of light and shade which its artist possesses. Any improvement in the colours of stained glass, whether in the recovery of the rich ruby tint of the middle ages, or by the invention of new combinations, would tell favourably on the glass manufacture in general; for we have yet seen only a little, in this country, of the application of colour to glass in miscellaneous manufactures. The practice of polychrome, or many-coloured decoration in buildings, is in its infancy among us; and it is hardly possible yet to conjecture what new aspects of beauty may in future be developed.

A question that suggests itself at the present time is—May not glass-staining be made available for a wider range of pictorial illustration than it has ordinarily been applied to? The ecclesiastical structures of the middle ages are those to which we are most indebted for specimens of this beautiful art; and in such buildings sacred subjects are necessarily adopted. Our modern English glass-stainers confine themselves, for the most part, either to sacred subjects, or to mere ornamental foliage, stars, arabesques, &c.; but the north-east gallery of the Great Exhibition shows us that our neighbours embrace a wider range. Look at MM. Marechal and Gugnon's 'St. Charles Borromeo giving the Sacrament to the Victims of the Plague;' and their 'Portrait of a

Burgomaster;' at Geyling's 'Girl at a Window;' and at Bertini's 'Dante Window,' in the central nave—these are of varied excellence; but they show that others beside sacred subjects may suitably be chosen. Mr. Baillie's 'Queen Elizabeth listening to the reading of Shakspere,' is suggestive as pointing out how exhaustless a store Shakspere himself would be to the artistic glass-stainer. A monument to this delicate art, and a monument to the great dramatist, might be formed by a series of dramatic scenes thus depicted. We need not go so far as to designate such supposed specimens "vitrified poetry" (in imitation of a modern German definition of architecture as being "congealed music"); but it may well deserve a thought, whether our glass-stainers could not strike out a new path for themselves, instead of following in the wake of mediæval artists. What glorious subjects might the Great Exhibition itself suggest, to be depicted in a range of "storied-windows!" Mr. Robert Hunt has well shown that the "poetry of science" is something more than a mere name; it can be felt as having a living warmth in it. And so is there likewise a poetry of industry, which, if appreciated by one who is at the same time a glass-stainer, might produce results of surprising force and beauty.

Whether future experimenters will verify the results remains to be seen; but M. Bontemps, in a paper communicated to the British Association at the Birmingham meeting in 1849, made known some experiments which touch very closely the labours of the glass-stainer. It is generally admitted that different metallic oxides impart different colours to glass; but M. Bontemps asks—How do *quantity*, and *time*, and *temperature*, affect the result? May not nearly all colours be produced by one oxide, varied by these contingencies? He sought industriously for true answers to these questions. He states that all the colours of the spectrum may be produced by oxide of iron; that purple, brownish-red, yellow, and green may be produced by oxide of manganese; and that the oxides of gold, of silver, and of copper, severally produce many different colours in glass—the determining causes being, the quantity of oxide employed, the temperature attained, and the duration of the process. Here we find sketched in outline an unbounded field for future experimenters; and science will belie itself if it do not, by and by, enable our glass-stainers (whether M. Bontemps' views be correct or not) to equal anything produced by the mediæval artists, so far as colour is concerned.

The above remarks concerning stained glass refer to improvements sought by a revival of taste or fashion in that department, rather than to the effects of fiscal changes. So far as the actual manufacture of the glass is concerned, the advancement lately made has not been considerable; it is in the combination of colouring materials with the glass that the talent of the glass-stainer finds most scope for its exercise. Not a few of the recent improvements, or attempts at improvement, relate to a combination of colours in the glass employed. We allude not here to stained glass, usually so called; but to adornments of a more special character. Take the question simply of *colour*. Here we find that the Bohemians, however far they may be below our level in manufactures, are able to impart to glass a richness of colour which our glass-makers have (until lately) endeavoured in vain to equal; the ruby tints especially are marked for their brilliancy. All colours in glass are produced by the admixture of some or other of the numerous metallic oxides; and although it is known that oxide of gold is used by the Bohemians in the richer red tints of the best specimens, yet for some reason or other (or more probably from a combination of reasons) our manufacturers have rarely

quite equalled those tints. It is evident, however, to any one who has glanced over recent productions, that sedulous endeavours are now being made to do all that our neighbours are able to do. The 'ruby' chandelier, and the 'Alhambra' chandelier, placed in the Great Exhibition, are steps in a style of art which may lead to results both brilliant and tasteful.

The production of glass *mosaics* is a very remarkable application of coloured glass to pictorial purposes. When Napoleon had possession of Italy, he ordered a mosaic copy of Lionardo da Vinci's celebrated picture of the 'Last Supper' to be made, the same size as the original, viz. 20 feet by 12. The artist was Giacomo Raffaelli; and the men under his direction, eight or ten in number, were engaged at it for eight years; this mosaic, which now belongs to the Emperor of Austria, cost £7500. The picture was, we believe, formed of cubes of coloured earths and stones; and therefore, however clever and effective, it does not belong to our present subject. The glass mosaics in the Great Exhibition, though few in number, are of distinguished merit, and are comprised among the scanty contributions from the once mighty Rome. No nation among the ancients equalled the Italians of the last two or three centuries in the production of mosaic glass pictures; for the ancient mosaics were for the most part in some kind of stone, clay, or pottery-ware, whereas the finest modern specimens are glass copies from paintings of the highest class.

The production of glass mosaics requires unwearied patience, combined with much skill and taste. In the first place, the materials of glass are mixed with various colouring materials, chiefly metallic oxides, so as to form opaque coloured enamels; these enamels are cast into slabs or flat cakes; and the slabs are cut into very small cubes or rectangular pieces. Not only is every colour imitated, but every gradation of tint in each colour; insomuch that, at the great mosaic establishment at Rome, maintained by the papal government, they have no less than *thirty thousand* different tints of coloured enamels, all classified and registered. With these little coloured cubes a picture is built up, copying some celebrated work of the Italian or other masters. The pieces are inserted, one by one, in a bed of cement which dries to extreme hardness; each piece is ground at a kind of lathe to the exact shape required by the particular tint in each part of the picture; and when the picture is completed by this extremely slow process, the surface is ground down and polished. It is quite impossible to describe the result thus produced; the reader can only appreciate it by looking at the actual specimens themselves. Let him examine the views of St. Peter's, the Coliseum at Rome, the Roman Forum, the Temple of Pæstum, the Harbour of Genoa, the Bay of Naples, the copy of Guercino's 'John the Baptist,' &c., in the Italian compartment of the Great Exhibition (mostly table-slabs): he will there find that the minutest touches, the most delicate tints, are imitated, and in some instances with surprising success. It must be remembered, too, that these colours are not mere surface tints, not merely 'skin-deep;' they permeate the substance of the glass, each little fragment having the same tint all through its thickness. If it were possible to turn the whole series of pieces upside down, without disturbing their relative positions, a second picture would be presented exactly like the original, only with a reversal of right and left.

The two specimens of glass mosaic described by Winckelmann and Count Caylus in the last century, seem to have been of a somewhat different kind, for they presented a complete picture on each surface. They consisted of coloured glass fibres fitted together with the utmost exactness, and cemented by fusion into a solid mass. Of these two specimens, each of which was

about an inch long by a third of an inch broad, one exhibited, on a dark ground of variegated colours, a representation of a duck; the outlines were decided and sharp, the colours beautiful and pure, and the effect very striking, from the artist having combined opaque with transparent glass; the most delicate pencil of the miniature painter could not have traced more accurately and distinctly, either the circle of the pupil of the eye, or the apparently scaly feathers on the breast and wings. The other specimen was about the same size, and exhibited an ornamental device of green, white, and yellow colours, which were traced on a blue ground, and represented volutes, beads, and flowers. On whichever side these specimens were viewed a similar object was perceived; for the pictures were formed of very slender fibres of glass, laid side by side, according to their colours, and afterwards exposed to a heat just sufficient to fuse the whole into a cemented mass, without disturbing or injuring the tints of any one fibre.

### Decorative and Silvered Glass Work.

To return, however, to decorative glass work belonging more particularly to our own day. Two remarkable novelties were patented by Mr. Pellatt a few years ago, founded on processes which had before to some extent been practised by the Bohemians. These are *Cameo Incrustation* and *Crystallo Engraving*. About a century ago, the Bohemian glass-makers excited surprise by producing bas-relief casts of busts and medals, enclosed within a coating of white flint-glass; and it was an extension of this art that became the subject of one of the patents mentioned above. To produce the desired result, the figure intended for incrustation must be made of materials that will require a higher degree of heat for their fusion than the glass within which it is to be incrusted; a mixture of China clay and silicate of potash is found to possess this quality. The bust or bas-relief is made of this material from a plaster mould, and after being slightly baked, is cooled gradually. A mass of transparent white glass is blown hollow, with one end open, and the clay cameo, heated to redness, is placed within it. The mass is pressed or welded to make the two substances adhere, and the remote end being closed, the glass-blower *draws out* the air from within (instead of forcing in air as in the ordinary manufacture), thus causing the glass to collapse, and to form one continuous substance with the cameo. When the glass is cut and polished to any desired form, the effect produced is striking and beautiful, for the clay cameo or bust has the appearance of unburnished silver, isolated in the midst of the solid transparent glass. Small articles are incrusted in a more expeditious manner, especially upon glass goblets or similar hollow vessels. The hot cameo is placed upon the hot manufactured vessel, a small piece of semi-liquid glass is dropped upon it, and this both fixes the cameo in its place and forms a glassy layer to enclose it.

The other novelty mentioned above, the *Crystallo Engraving*, consists in taking fac-similes of casts or dies from intaglios, and compressing them in intaglio on hollow glass vessels. This process is conveniently adopted where numerous copies of elaborate devices are required, such as badges of regiments, or arms upon decanters or table glass. The die or cast is sprinkled over first with Tripoli powder, then with fine dry plaster and brickdust, and then with coarse powder of the same two materials; it is placed under a press, and at the same time exposed to the action of water, by which the sandy layers become solidified into a cast. This cast is placed in the iron mould in

which the glass vessel is to be made, and becomes an integral part of the vessel so produced; but by the application of a little water the cast is separated, and leaves an intaglio impression upon the glass as sharp as the original die. The cast or cake thus used, however, seldom suffices for a second impression.

The mention of the Bohemian glass manufacture brings to mind a curious example of the mode in which commerce seeks out its markets, and makes light of the distance which often separates the producers from the consumers. In the Great Exhibition is a glass case of a very instructive kind, containing specimens of all or nearly all the commodities brought to Liverpool in the common course of trade. Each specimen is labelled with its commercial or local name, its scientific name (if any), the country whence imported, the uses to which applied, and the quantity imported into Liverpool in 1849. Among the articles so deposited are Bohemian glass beads, of all sizes and colours; and the route by which they reach their destination is curious. They find their way from Bohemia northward to Hamburg, or southward to Trieste; they are shipped at one or both of those ports to Liverpool; they are shipped again from Liverpool to the west coast of Africa, where they are bartered with the natives for ivory, palm oil, or other commodities.

Those who are attracted by the brilliantly-coloured and diversely-ornamented specimens of glass which now appear in the London shops, may hardly know that such articles were a staple manufacture in Venice in the sixteenth and seventeenth centuries, and that much of the modern work is a mere revival of a partially forgotten art. Mr. Pellatt, in his interesting 'Curiosities of Glass Making,' enumerates the following among the tasteful productions of the Venetians. The *Venetian ball* has an exterior of transparent colourless glass, enclosing glass of many different colours fused into one mass. The *Venetian filagree*, which consists of spirally-twisted plain and coloured enamel glass, was much used by the Venetians for the stems of wine-glasses, goblets, &c.; and when placed together side by side in alternate colours, it was manufactured into tazzas, vases, and other ornamental articles. *Millefiore glass* consists of a great variety of ends of fancy-coloured tubes, cut sectionally at right angles with the filagree cane to form small lozenges or tablets; and these, when placed side by side, and massed together by transparent glass, have the appearance of an innumerable series of flowers or rosettes for ornamental vases, &c. *Mosaic glass* was produced by threads or small canes of variously-coloured opaque or transparent glass, of uniform lengths, ranged sectionally together in groups, so that the ends may form grounds on which are patterns of flowers or arabesques; and these, being cut either transversely or obliquely, form slabs of any required number or thickness, the same pattern being met with at every cutting. Of such kind were the two specimens described by Winckelmann. *Smetz glass* is produced by fused lengths of coloured glass rolled one into another, so as to imitate carnelian or other stones. *Vitro di trino* is fine lace-work, with intersecting lines of white enamel or transparent glass, forming a series of diamond-shaped sections; the centre of each has an air bubble of uniform size. The *Frosted glass* has irregularly-veined marble-like projecting dislocations, with intervening fissures. It is produced by plunging the white-hot glass into cold water, and then reheating and reblowing it; although it appears covered with fractures, this glass is perfectly sonorous. Mr. Pellatt says that the art of making this glass was known and practised only by the Venetians, until revived by him a few years ago at the Falcon Glass Works.

The silvered glass produced by the method of Mr. Hale Thompson is a product of singular beauty. Whether in the form of cups or goblets, of tazzas or wine-coolers, of epergnes, ewers, candelabra, inkstands, salt or sugar-boxes, of flat mirrors or of mirror globes, it exhibits a brilliancy of hue that can hardly fail to arrest attention. It is to the combination of *colour* with *silvering* that we owe this result. Some months ago, Mr. Donaldson, in advocating the use of this material for architectural decoration, especially in the adornment of shop-fronts, stated that the influence of the silver on the colour gave rise to tints almost unknown before, and such as no combination of the ordinary colouring ingredients could imitate. It may, in this respect, be compared to the *Diorama*, which differs from other pictures in being viewed by reflected and transmitted light conjointly; the glass presents the reflective power of the silver with the transmissive or transparent power of the coloured medium. The most conspicuous products, perhaps, are the mirror globes, which present every variety of brilliant colour, and have a size from two inches to thirty inches in diameter; but, excellently as these illustrate the combination of effects just alluded to, they are not so delicately beautiful as articles of more diverse form, where endless *nuances* are produced by the different angles at which the light is reflected to the eye. So much more brilliant is the argentine reflection than that produced by the mercury-amalgam at the back of a looking-glass, that it is contemplated to employ this glass in many useful ways for optical and scientific instruments.

Without going minutely into details, a few words will suffice to explain the relation which this new method bears to those ordinarily adopted. In preparing a looking-glass, a sheet of tinfoil is laid down smoothly on a flat table; liquid mercury is poured on it, the plate of glass is laid on the mercury, and heavy weights are laid on the glass; while the superfluous mercury is gradually expelled by the pressure, the remainder combines chemically with the tinfoil, and forms with it an amalgam which adheres pretty closely to the surface of the glass: when seen from the other side, this amalgam yields the brilliant white reflection familiar to us in looking-glasses. But, brilliant as is this reflection, it has often been thought that a yet more lustrous effect would be produced by the use of real silver; and a patent for this object was procured by Mr. Drayton, about eight years ago. According to this patent, the plate of glass is covered with a solution, in which the chief ingredient is nitrate of silver; and when this solution has been left undisturbed for a certain time, metallic silver separates from it, and becomes precipitated on the glass; the remaining solution is poured off, and the film is secured by a resinous varnish. In the later silvering process a somewhat similar nitrate solution is employed, but with a different precipitating agent. The remarkable feature, however, is, that the glass is made *double*, and the liquid is poured into the cavity between the two surfaces, so that no protecting varnish is necessary; and as the twin thicknesses may be of different coloured glass, an extensive range of new effects becomes obtainable.

The *etching* or *engraving* of glass presents another pleasing variety. By Mr. Kidd's recently-patented process, a species of embroidery of great beauty is produced. In this method, the devices or patterns are cut on the *under* surface of the glass, and the small facets are silvered; the result is, that innumerable tiny mirrors throw up reflections in every direction. This is the case where colourless transparent glass is employed; but where multi-coloured glass is used, many novel combinations present themselves. There may, for instance, be a basis or primary layer of transparent glass; then

an opaque layer of white glass is poured upon this; and, lastly, a layer of ruby glass on the white; the united thickness may be then cut to any depth and with any device, and, whether silvered or not, a rich display of colours results. Specimens of Kidd's embossed glass, as well as of the silvered coloured glass, are to be met with in the Exhibition, and certainly form notable features among its novelties.

Our American brethren seem to have been the first to introduce a mode of manufacturing glass by *pressing*, being one of the very few varieties in which *blowing* is not required. A metal die and plunger are prepared, the former to give the exterior pattern, and the latter the interior pattern, to the article about to be made; the ball of melted glass is dropped into the die or mould, and the plunger or matrix is brought down upon it by the lever handle of a simple kind of press, and the glass is thus instantly formed into the desired shape. The process is said to be cheap and expeditious, but to require much skill. If the quantity of glass be too large, the overplus gives considerable trouble; if too little, the article is spoiled: if the die and plunger be too hot, the glass will adhere to them; if too cold, the surface of the glass becomes cloudy and imperfect. It is by some such process as this, but still more simple, that *glass drops* for chandeliers are ordinarily formed. Lumps of glass, made expressly for this purpose, are softened by heat, and shaped in twin brass dies; but the inferior kinds are made from thick tumbler bottoms, or waste glass. The arms of chandeliers, also, are pressed by twin dies, the upper die being fixed to the plunger, and the under one to the bed of a lever press.

A mode of decorating glass, which leads to many varied and beautiful results, is that carried on by the patent of Messrs. Powell. In manufactures of this description, after the glass is made, and before it has cooled, a device in intaglio is impressed by a die, just as in making impressions in wax, and into the cavities thus formed melted glass of another colour is poured; when cold, the surface is properly ground and polished. It is difficult to imagine the play of colours thus produced; for, besides the contrast between the two kinds of glass employed, there are all the multiplied tints which result from prismatic reflection, according to the angle at which each small surface presents itself to the eye.

### Scientific Relations of Glass-Making.

But we must now direct our attention to a few improvements more solidly advantageous than those which owe their attractions to colours, mosaics, silvering, or embossing.

Every day's experience tells us that there is a perpetual reaction between the different departments of knowledge. Every science and art receives benefit for every benefit which it confers; it "gains strength in giving." If science aids the glass-maker, so does the glass-maker lend his aid to the students of science. A curious exemplification of this has appeared within the last few years, in connection with the beautiful palm-house at Kew, chiefly through the instrumentality of Mr. Robert Hunt. To explain it, we must remind the reader that ordinary solar light consists of rays of three colours, red, yellow, and blue; and that of these three the red have the most heating effect, the yellow the most light-giving effect, and the blue the strongest chemical effect. When combined in the ordinary ratio, the sun's rays produce the regular or natural effects (whatever they may be) on vege-

tation; but if artificial means be adopted to change this ratio, special effects result. Mr. Hunt employed coloured glass to determine these effects; for, in each kind, the glass transmits one portion of the solar rays more abundantly than the rest, and owes what is called its 'colour' to this property. Under *yellow* glass, he found that, generally speaking, the germination of seeds is prevented; and that, even in cases where it has commenced, the plant speedily dies. On the other hand, in a later stage of development, these rays seem to contribute to the vigorous growth of the plant. Under *red* glass, if the seeds are well watched and watered, germination takes place; but the plant shows a sickly constitution, and the leaves are partially blanched. It is curious that, according to Mr. Hunt's observations, those plants which naturally bend towards the white light of day, seem to shun red light by bending away from it; but that when they arrive at the flowering stage, the plants welcome the red rays more than the blue or yellow. Under *blue* glass, the germination of seeds and the growth of young plants are accelerated in a remarkable manner; but if this kind of stimulus be continued beyond a certain time, the plant increases in bulk without a corresponding increase in strength. Mr. Hunt, in others of his published works, has applied the term *actinism* to the peculiar principle and effects of the blue rays; and, in connection with those views, he expresses an opinion that these experiments on the effect of coloured glass on plants, "seem to point to a very great practical application, in enabling us in this climate to meet the necessities of plants, natives of the tropical regions. We have evidence (at least so it appears to me) from these and other results, that the germination of seeds in spring, the flowering of plants in summer, and the ripening of fruits in autumn, are dependent upon the variations in the amount of actinism or chemical influence of light and of heat, at those seasons, in the solar beam." These interesting facts, it is true, belong to the optical and organic sciences rather than to the glass manufacture; but it is impossible not to see how mutually beneficial such discoveries must be to the two friendly powers—science and industrial art; and the new palm-house at Kew affords at once a case in point. When a little manganese is present in glass, it corrects the colouring action of the iron which usually exists in the sand; but the whitened glass thus produced is found to admit the heat of the solar rays to a greater degree than ordinary glass; and the plants in a palm-house or hot-house so glazed are found to suffer a scorching effect injurious to them. Mr. Robert Hunt, appreciating both the good and the bad aspects of this modification, has exercised his ingenuity in retaining the former and dispersing the latter; he recommended the use of a little oxide of copper instead of oxide of manganese; and the palm-house at Kew, glazed with glass so tinted, has been found to possess the advantages without the disadvantages of what we may term the manganese system.

The manufacture of glass suitable for optical purposes has been (as we have before noticed) unduly pressed down in England by the pernicious Excise laws, only recently removed; and we have to wait for future times to show the full effect of the removal. The production of glass fitted for the construction of lenses for large telescopes, is a work of such extreme difficulty, that those who excel in it become celebrated throughout Europe, and their names find a place in the records of science. Thus Frauenhöfer, of Munich, has a world-wide fame (among men of science at least) for having, among other works, produced the object-lens for the great telescope at Dorpat. His successor, Utzschneider, maintains his reputation for producing optical glass

free from striæ or streaks; Guinand, Frauenhöfer's pupil, carried a share of the same reputation to Paris; and Bontemps, Guinand's successor, is at the present day taxing his skill to equal, if not to excel, his predecessors. Is it not lamentable that, until the year 1845, English glass-makers were almost wholly prevented from competing for these honourable distinctions? Until recently, the dioptric lenses for lighthouses, on the principles laid down by Fresnel and Brewster, have been chiefly manufactured on the Continent; but our English makers are now endeavouring to enter into honourable competition with their neighbours. It is most encouraging to find the Astronomer Royal speaking as follows, at the recent meeting of the British Association at Ipswich:—"The removal of the vexatious fiscal interferences with the manufacture of glass, and the enterprise with which Mr. Chance as manufacturer, and Mr. Simms and Mr. Ross as opticians, have taken up the construction of large object-glasses, promise to lead to the most gratifying results. Already Mr. Simms has partially tested object-glasses of 13 inches' aperture; and one of 16 inches is waiting not for the flint, but for the crown lens. Mr. Ross, it is understood, has ground an object-glass of 2 feet aperture, but it has not been tested. The facility of procuring large object-glasses will undoubtedly lead to the extensive construction of graduated instruments on a larger scale than before."

The manufacture of glass tubes for a multitude of purposes is among the most notable results of the removal of the Excise duty. Such articles could scarcely have been made with any chance of remunerative profit under the harassing restrictions of the old laws; but several patented processes are now at work, by which glass pipes are made for the flow of water, corrosive acids, gas, &c. In the Mineral Section of the Great Exhibition, at the extreme southern side of the British department, many specimens of this glass tubing may be seen.

As there are many circumstances which show how the scientific principle of *annealing* or *tempering* improves the quality of manufactured articles in glass, so, conversely, does the manufacture afford striking exemplifications of this principle. If we were to speak of natural magic in glass-making, we might perhaps select the *Bologna phials* and the *Rupert drops* as examples of its exercise; for assuredly there are few things in this art so utterly perplexing to an observer. A Bologna phial is a phial of any convenient shape, which differs from an ordinary phial only in being much thicker at the bottom than the sides, and in having been suddenly cooled in the open air instead of slowly cooled in an annealing oven. The result on its susceptibility to fracture is most extraordinary. It will bear a heavy blow or severe pressure from any blunt instrument uninjured; but if any hard and angular substance—even so small as a grain of flint or sharp sand—be dropped into it, the bottom of the phial will crack all round and drop off. A small fragment of diamond has even been seen to pass through the thick bottom with apparently as little resistance as if it dropped through a cobweb. Instances have been known in which one of these phials has been struck by a mallet with a force sufficient to drive a nail into most kinds of wood, without fracture; while a two-grain fragment of flint, dropped gently into the phial, cracked and severed the glass. The *Rupert drops*, or *Prince Rupert's drops*, are small solid pieces of green glass, which have been dropped while red-hot into cold water, and which take the form of rounded lumps elongated by a tail. The round part will bear a hard blow without fracture; but if the smallest particle of the tail be broken off, the whole flies into innumerable fragments as fine as dust. It has been even

shown that if this experiment be performed while the glass drop is in a wine-bottle filled with water, by the aid of a long pair of nippers, the concussion by the explosion (for it almost amounts to an explosion) is so violent as to break the bottle and scatter the water in all directions. All these strange results are due to a peculiar inequality in the condition of the glass, arising from the sudden cooling; but it has not yet been clearly ascertained wherein the inequality consists. At any rate, it is a phenomenon equally strange and beautiful.

Were we to dwell upon the many curious relations which glass bears to scientific principles, either as a consequence of them, or as an aid towards their development, it would take us far beyond our limits. We may however mention a circumstance very little known in common life, that there are certain kinds of glass which may be *dissolved* in water. All glass is, chemically, a silicate of some alkaline or metallic oxide; and according to the nature of this oxide, so does the quality of the glass differ. If potash or soda be the substance combined with the silicic acid or silica, without any third ingredient, a glass is produced which, though presenting the usual vitreous aspect, is easily dissolved in water. It is called *soluble glass*, and is employed as a kind of paint for paper, cloth, wood, &c., to prevent or retard their inflammation on the contact of an ignited body.

## New Applications of Glass.

In respect to the every-day wants of society, we find that glass is gradually working out the scheme which we noticed as marking the progress from 1801 to 1851. The raw materials, it is true, have not been largely increased in number or kind; but commerce has given us a few (such as Australian sand), science a few (such as an extended knowledge of the metallic oxides), and legislation a few (such as cheapening the alkalies). The manufacturing processes have, from the reasons so many times alluded to, only of late shown any marked improvement; but these improvements lie in many different paths, all of which are now being pursued simultaneously. There are new but simple apparatus brought into use; there are new combinations of the primary ingredients; there are new mixtures of metallic oxides to impart colour; there are improved rules adopted concerning the temperature, the duration, and the manipulative details of each process; and there is a common-sense tendency to employ a few foreign workmen when (but only when) the English hands are not skilled in any particular department. But it is in the *application* of glass to practical purposes that we most clearly see the recent progress. There is both an increased use where it has long been used, and a new use as a substitute for other materials—both being due to the increased cheapness and excellence of the glass made.

The use of glass for agricultural and other purposes has indeed extended with striking rapidity since the change in the Excise duties. Let us take the shop-bill of one among many London manufacturers of these articles, and glance through its contents. First we find patent rough plate-glass, an eighth of an inch thick, obtainable in sheets up to a size of ten or twelve superficial feet, for conservatories and skylights, and saleable at threepence to tenpence per foot. Horticultural sheet-glass for conservatories is "made so as to obviate the scorching effects of the sun's rays." Rough plate-glass, intended for roofs and floors, is made from a quarter of an inch to an inch and a half in thickness; so strong are the thickest of these specimens, that they are walked

over by thousands of pedestrians in the busy streets of London, in spots where light is required to be thrown into an underground cellar. Glass tiles are made of rough plate from one-eighth to one-half an inch in thickness, and of sheet-glass from sixteen to thirty-two ounces per square foot; and glass slates, drilled with holes for fixing, are made of similar materials. Glass shelves, with or without raised edges, and from two to six inches in width, are sold by the foot of length. For immediate horticultural or daily use we find bee glasses, propagating glasses, cucumber glasses, hyacinth and flower dishes and glasses, crocus glasses, wall-fruit glasses, fruit-protecting glasses, peach and grape glasses, fern shades, milk trays and pans, cream-pots, and numerous other articles. Then there are numberless useful implements which can with difficulty be brought under any common designation, but which all tend to exemplify the increasing use of glass; perforated glass for ventilation, syringes for injections, chemists' pill slabs, cornice poles, pipes for conveying liquids—are each of them types of large classes of articles now made of this material.

In respect to the ability of English workmen to equal those of foreign countries in the mechanical departments of the glass manufacture, Mr. Paxton adduced an instructive instance some time ago. In one of the many public explanations which he has given concerning the Exhibition and its wonders, he dwelt (among other things) on the apprehended injury which foreign workmen might inflict on those of this country. "He would state a fact within his own knowledge. Frenchmen were celebrated for ornamental glass. The establishment of Messrs. Chance employed a number of Frenchmen for a particular branch of the trade, the making of glass shades. By degrees the English workmen in the establishment became as proficient in the art as the French; and about a fortnight ago a trial of skill took place between them. The establishment received orders for an enormous glass shade. A Frenchman tried his skill, and failed; an Englishman, who, previous to the importation of the French, was unacquainted with the art, then made an effort to accomplish the task, and succeeded at the first attempt."

## The Glass Work of the Crystal Palace

That the already renowned Crystal Palace—that eighth wonder of the world, which could have contained six out of the seven old wonders under its roof—could not have been built half-a-dozen years ago, is a truism which we have before adverted to; and without dwelling more on this point, it will always remain a matter of interest to note the arrangements by which the palace *has* been built. The manufacture by Messrs. Chance of the acres of glass which the building contains, was in itself an industrial feat worthy of record.

The neighbourhood of Birmingham produced both the iron-work and the glass-work for the Exhibition building. Messrs. Chance's establishment is situated in a suburb called Spon Lane, surrounded by the smoking chimneys of various factories. It is a vast place, covering an area about equal to that of the Crystal Palace itself, but, unlike it, scattered and disjointed, with no two buildings alike, and no symmetry of arrangement. Like many other of our manufacturing establishments, it has grown with the growth of trade; it has extended its limits to embrace more and more buildings, as the exigencies of the manufacture required, and has not had time to put on those outward adornments, or to adopt those symmetrical arrangements, which a wholly modern building might present. This very circumstance, however,

gives it a peculiar interest; for the building embodies within itself an epitome of the history of the manufacture—rapid growth, wide extension, intense activity, gradual adaptation; these distinguish both the building and the manufacture. Messrs. Chance originally confined their attention to one or two kinds of glass, but they have now a thousand persons employed in making crown, sheet, plate, shade, and coloured glass; and during the production of the glass for the Crystal Palace, the number of operatives was far greater. How wonderful are the glass shades deposited by this firm at the Exhibition, and how remarkable that these shades are made by the same process as the glass for the building itself! It is now about twenty years since Messrs. Chance introduced into this country the mode of making sheet-glass, adopted before that time by the French and Belgians; and the manufacture has gradually become an important one. Anything more striking than the details of the manufacture can hardly be met with in the whole range of industry. The workman dips his iron tube into the semi-viscid glass, and takes up a quantity amounting to 12 or 14 lbs.; he rolls the mass on a wooden block, till it assumes a cylindrical form; he applies his mouth to the other end of the tube, and blows until the mass assumes a hollow ovoid form; he whirls this round his head, or, rather, in a vertical circle 10 or 12 feet in diameter, and elongates the ovoid into a cylinder with rounded ends; he re-heats the glass two or three times during these processes, to maintain the proper consistency, and at length the remote end of the hollow mass gives way, and we have before us a cylinder of glass, attached only at one end to the tube. In respect to the glass for the Crystal Palace, the cylinders were made somewhat more than 4 feet in length. The cylinders are dissevered from the tube, and are cut lengthwise with a diamond; they are placed in a kiln, where the heat gradually opens the fissure, and there is finally presented a flat piece of glass, which can be cut to any smaller size.

It is sufficiently notable that the glass for the Exhibition should be so produced; but that the shades which are deposited in one of the galleries should also have been produced by the same whirling process, almost passes belief. Under the immediate pressure of the immense demand, Messrs. Chance invited over a few skilled workmen from France and Belgium; but the English hands—urged by this proximity to do their best—have learned to equal their rivals; and the shades here spoken of are of English workmanship:—72 inches by 13, 62 inches by 26, 88 inches by 18—such are the enormous dimensions of three of these shades. The exact form is given to the shade by pressing the blown cylinder gently into a mould of the required shape, while the glass is yet soft. Never, surely, is material more under the command of the workman, than glass under that of the glass-blower.

The account which Mr. Paxton has more than once given of the origin of his plan of the Crystal Palace may be here briefly adverted to, so far as it illustrates the availability of glass as a building material. In 1828, when his attention was first directed to this subject, the forcing-houses and hothouses at Chatsworth were formed of coarse thick glass and heavy woodwork, which rendered the roofs dark and gloomy. His first reform was to lighten the rafters and sash-bars by bevelling off their sides. A second improvement was that of cutting grooves for the reception of the glass, by which there is much less exposure (than by the old method) of the putty to the destructive action of heat and moisture. The use of iron in various structures having by that time become very general, Mr. Paxton proceeded to inquire whether iron sashes and rafters would be available for glass structures; but the result of his

inquiries was unsatisfactory, for he found that such iron framings were more costly than wood, that the sashes were liable to become disjointed by expansion and contraction, that the glass would be fractured by such disjointing, that the temperature of metal framings varies more than that of wood, and that the repairing of injuries would be less simple and expeditious. The combination of wooden rafters and frame-work with iron sash-bars was then tried, but the advantages did not equal the disadvantages; and Mr. Paxton has since that period uniformly adhered to the employment of wood in immediate contact with glass. His next investigation led him to the "ridge and furrow" system of glass-roofing. In most glass structures employed for horticultural purposes, the lean-to roof inclines downwards towards the south, in order to catch the heat of the sun; but a consequence of this is (especially if the sash-bars be thick and clumsy) that the east and west or morning and evening sun exerts very little power within the structure, while the midday heat is received in all its fierceness. To obviate this, Mr. Paxton contrived the ridge and furrow arrangement, at such angles as to increase the reception of morning and evening rays, and check somewhat the midday rays. He built a pine-house in 1833, and a greenhouse in 1834, on this principle; and in 1836 he constructed a curvilinear hothouse, 60 feet in length by 26 in width, with an elliptical roof on the ridge and furrow principle, the sash-bars being of wood: this was, in fact, the first germ whence the indescribably beautiful transept arch at the Crystal Palace proceeded. When the great conservatory was commenced at Chatsworth in 1837, Mr. Paxton availed himself of the use of a machine for shaping and planing the sash-bars. He also availed himself of the sheet-glass which Messrs. Chance had by that time brought into use; and it was by his suggestions, and offers of purchase, that the firm redoubled their efforts until sheet-glass four feet in length could be made: this enabled Mr. Paxton to employ grooving instead of overlapping in glass roofs, a system to which the Crystal Palace owes no small portion of its efficiency. The next step was to make the ridge and furrow rafters *horizontal*, instead of inclined, as they are in the Chatsworth conservatory; and three buildings were constructed with roofs on this principle, viz. a conservatory in Darley Dale, an ornamental glass covering to a conservatory wall at Chatsworth, and the new Victoria Regia house in the same princely domain. The last of these three buildings was constructed in 1850; and it was while the subject was thus fully occupying his mind, that the happy idea of the glass palace occurred to Mr. Paxton, and enabled him and others to surmount obstacles which seemed likely to overwhelm all parties concerned.

To describe this wonderful roof, these sixteen acres of glass, is barely necessary; for the daily and weekly journals have made the subject familiar to almost every one. Yet we cannot rightly understand the relation which the glass manufacture bears to it without recapitulating a few details.

First, then, we have in the roof a structure of such unusual lightness that the whole weighs but 3½ lbs. per square foot, glass and wood included. This slightness of pressure on the girders and columns beneath has been a point of considerable importance and value; for it enables the builders to rely securely on a degree of strength in those parts which would be quite inconsistent with the pressure of an ordinary roof. In the remarkable "ridge and furrow" principle of this roof, the *Paxton gutters*, as they are called (we stay not to investigate the claims of other parties to the invention), are ranged parallel at distances of 8 feet apart; and the ridges are midway between the gutters, both gutters and ridges running east and west. The ridges are so

The mode of glazing these almost innumerable sashes was as follows:—The gutters, the ridges, and the principal rafters being fixed in their places, one of the long or 49-inch edges of a sheet of glass was inserted into the groove of the principal rafter; a sash-bar, measuring 1 inch by 1½, and double grooved, was then put on to the other long edge of the glass; the sash-bar was next brought down and secured at the top to the ridge, and at the bottom to the edge of the gutter; the lower edge of the glass being bedded upon a layer of putty three-quarters of an inch broad, a slight blow to the lower end brought the upper edge of the glass home into the groove in the ridge. The glass being then pressed down, the putty was made good in the grooves externally.

In glazing the *vertical sashes,* which form in part the walls of the building, pieces of glass were employed about equal in dimension to those in the roof; the glass was slipped down between the sash-bars. Both in the roof and in the vertical sashes provision was made for mending or replacing broken panes, by causing one groove to be cut deeper than the other, so that the glass might be slipped in from one side, and puttied into its exact place.

But the glazing of the vaulted transept was the masterpiece. Scarcely anything else in the building called for the exercise of more caution and ingenuity, on account of the curvatures which the vault presents. In the lower part of the circular arcs, where the direction of the ridges and furrows does not depart far from the perpendicular, ladders and temporary scaffoldings enabled the glaziers to proceed with their labours; but as they ascended, ordinary means became insufficient, and a very ingenious box or stage was constructed for their accommodation. This box moved on wheels in the line of the gutters; it was suspended from the lead flat which runs along the summit of the transept, and was lowered to any part of the curve at which the glaziers were at work, being brought sufficiently close to the curved ribs and gutters by ropes and tackle. The glazing of the flat roof of the nave was little (if at all) less difficult than that of the transept, owing to the absence of any supporting terrace or passage on which the glaziers might stand. The ever-ingenious contractors devised a machine (of which seventy-four were constructed), each capable of accommodating two glaziers. The machine consisted of a frame of deal about eight feet square, with an opening in its centre sufficiently large to admit supplies of glass, sash-bars, putty, &c., to be hoisted through it from the ground beneath; the stage rested on four small wheels, which travelled on the Paxton gutters (the width of the machine being made exactly equal to the space from gutter to gutter); and the machine then spanned over one ridge and two sloping sides, being a little higher than the ridge. The workmen were protected in bad weather (of which they had a full wintry share) by a canvas awning. The men sat at one end of their stage, and pushed it along about a foot at a time as their labours pro-

ceeded; they inserted and puttied the panes of glass one by one, and thus travelled with their machine from the transept towards the east or west end. So dexterous did the glaziers become in the use of these machines, that eighty of them put in upwards of 18,000 panes of glass, equal to more than 62,000 square feet, in one week. The greatest quantity put in by any one man in one day was 108. For repairing the roof, a machine has been contrived, the wheels of which rest upon the ridges instead of upon the gutters.

We feel strongly tempted to add to the above details a description of the very curious apparatus—first employed by Mr. Paxton, and then improved by Mr. Birch—for making and grooving the sash-bars; but these relate to working in wood (an instructive subject in itself) rather than in glass, and scarcely fall in with the object of the present paper. In respect to the humble material, *putty*, employed in this unexampled specimen of glazing, its chief point of interest is the largeness of the quantity called for: it was consumed not simply by pounds or by hundredweights, but by tons. If some of this putty has proved treacherous, and has admitted a sprinkling of rain into the interior of the building, we may well excuse it, and wait patiently until the industrious glaziers have made all weather-proof. Let us put to ourselves this question, and think well before we answer it—If brick, stone, and mortar had been the materials for the Exhibition building, instead of iron, glass, and putty, would the year 1851 have witnessed the Great Exhibition at all?

Many have been the doubts and queries respecting the thickness of the glass employed in the Crystal Palace. At one of the meetings of the Society of Arts, questions were put to Mr. Fox on this subject, to which he replied nearly as follows:—He "thought the glass quite strong enough, or he would have made it stronger; because he had to keep the glass in repair for twelve months. But there was one important point connected with glass which few considered when they put questions respecting it: they only asked what thickness it was. Now its thickness was very important, but the width was equally so. If they got a piece of glass of a certain thickness and width, and found that hailstones broke it, let them reduce the width, and they would find that it would bear the force of the hailstones. Now the panes used were 16 ounces to the foot, 49 inches long by 10 in width. During the last twelve years they (Messrs. Fox and Henderson) had used upwards of thirty acres of glass, spread all over the kingdom, a great deal of it being used at the royal dockyards and at railway stations. It had almost all been 16-ounce glass, and some was as low as 13-ounce; and although it was spread over twelve years, they had had no difficulty with it whatever. But if, instead of 10-inch width, they had made it 15, they would have had it broken in every hailstorm." This evidently goes to the root of the matter; the thickness may be safely diminished in about the same ratio as the width; and experience alone can show what is the requisite thickness for a given width. The contractors, from the terms of their agreement, had abundant reasons for wishing to make the glass strong enough to resist hailstorms.

The Crystal Palace system of glazing (if we may so designate it), in which the roof and the skylight are one, seems likely to meet with many valuable developments. A farmer in the West of England has recently roofed with glass a *barn* more than 100 feet long by about 30 in width. The expense has been far less than that of a slate roof, while the anticipated advantages are many, and have been thus commented on:—"The barns may be applied to drying corn during a catching harvest. The corn can be placed in the barn immediately upon being reaped, where it will have the benefit of the sun when

it shines, be protected from the showers, and also dried by artificial heat if required, and then stacked in ricks under a covered stack yard. This will enable the land to be immediately ploughed up and sowed with turnips or rape, which will prepare the land for another cereal crop the following year; so that he (the farmer) anticipates three crops in two years." If the *Western Times* is here correct, and if the farmer's anticipations are really sound, he will indeed have cause to bless the Crystal Palace, and those who have been instrumental in rendering the construction of it possible.

Of the contents of the Hyde Park structure, many of those which illustrate the glass manufacture have already been adverted to; and the industrious visitant to that unparalleled collection will have no difficulty in calling others to mind. In the *Sunderland* compartment, for instance, we meet with Messrs. Hartley's model of a glass-house and eight-pot furnace, on a scale of an inch and a half to the foot; a glass-melting pot, of Stourbridge clay, so large and thick as to weigh nearly a ton when empty, and two tons when filled with molten glass; a series to illustrate the crown-glass manufacture, exhibiting the glass in thirteen successive stages of its progress; a similar series for sheet glass, in eleven stages; a sheet of ruby glass, 51 inches by 39; a ruby cylinder of glass, fitted to produce a sheet nearly of those dimensions; and various applications of glass to useful purposes. France, Belgium, Germany, Austria—all send specimens of glass-making, some of which are highly curious. A French chimney-piece made of glass plates and cut glass, and an imitation of flowers made of glass thread, are examples to which other materials would have been better adapted; but there are not wanting abundant specimens of fitting and tasteful adaptation of this delicately-beautiful substance.

In respect to foreign countries, as the glass manufacturers have had no Excise laws to contend against, so have they had no sudden impulse by the removal of such laws, but have proceeded in a steadily advancing course. France once excelled us in plate-glass; we now equal her. France and Belgium taught us how to make sheet-glass; we now equal or excel our teachers. If, in flint-glass, France still excels us (as some think) in graceful forms and delicacy of adornment, let our Schools of Design do their best to bring the English workmen up to the proper level. If, in stained glass, Bohemia, or Italy, or France, still excel us, let our chemists, working hand in hand with our glass-makers, tire not until they have discovered why the superiority exists, and how it may be attained. And in the meantime, wherever we find a foreign neighbour who can excel us—in colours, in form, in durability, in cheapness—let us not hesitate to give honour where honour is due: it is not only the most just policy but in the end it will also be the most profitable.

# IRON AND ITS MANUFACTURE.

If we glance at the aspects which the iron manufacture has presented between 1801 and 1851—the first half of an eventful century—we find that changes and advancements have been made in the *processes* and the *application*, rather than in the *materials*. In truth it could hardly have been otherwise; for iron, absolutely pure iron, is one of the small number of simple chemical substances, not compounded of any other two. In the forms, however, which the metal assumes when manufactured, there are always small quantities of carbon and other substances combined with it; and as these substances impart valuable qualities to the iron, busy researches have been made to determine the exact relation between the substances and the qualities. So far, then, materials have undergone modification; but it remains true, as noticed above, that processes rather than materials mark the course of recent improvements.

The glass manufacture, as was explained in the former article, had an uphill struggle against the legislature until within the last half dozen years; and all attempts at improvement were nearly paralyzed until that struggle reached a successful issue. This has not been the case in respect to iron. The legislation concerning this important metal has—happily for all parties—been small in amount. The miner may dig and the roaster may calcine, the smelter may reduce and the founder may cast, the blacksmith may forge and the whitesmith may file—without obstruction, or at any rate without the unwelcome visitation of the exciseman. The duties on the import of foreign iron or iron manufactures, or on the export of those of British produce, have not during the present century been very heavy; and although the spread of liberal commercial views has been felt in this as in other departments of industry, yet it is not in such direction that we are to seek for the main cause of the recent great advancement in the manufacture now under notice.

It is not intended (as has been already announced) that this series of papers should contain systematic descriptions of the manufacturing processes, or of the local centres, of industry; for such details we refer to the two Cyclopædias, and shall assume that the reader has a general every-day acquaintance with them. Almost every one, for instance, who is competent to understand even a common newspaper, is aware that the south of Wales, the centre of England, and the south-centre (if we may so designate it) of Scotland, are the chief seats of the British iron manufacture. But when we go beyond these primary facts we find abundance of "Curiosities," both in the localization and the processes of this all-important branch of industry.

## Local Peculiarities.

Strange, indeed, are the changes which have occurred in the chief seats of this manufacture. Who, among the thousands who know Sussex as an agricultural and pleasure-touring county, have detected or could detect any indication that it was once an iron-making district? Yet such was once its character. The sand which Sussex presents in such large quantity contains a rich per-

centage of iron; and this iron used formerly to be extracted by smelting on the spot. If the reader should ask whether the sand is less ferruginous than formerly, or (if not) why the manufacture has fallen off, the answer is a simple but significant one. Until the last century all iron was smelted in this country (as in others) with charcoal, and this charcoal was uniformly made from the trees which grew in or near the iron district; but this practice has been nearly superseded by the use of coal and coke. A timber tree, the growth of a century, may be consumed in a few weeks or even days in smelting operations; the consumption is much more rapid than the growth; and it thus happened that the making of charcoal for the smelting of iron was one chief cause of the great destruction of our ancient woods. Evelyn made a kind of sorrowing complaint against Nature, for having "thought fit to produce this wasting ore more plentifully in wood-lands than any other ground, and to enrich our forests to their own destruction;" and he utters a "deep execration of iron mills, and iron masters also." If he could have lived to see the day when Sussex, by becoming too thinly supplied with timber fuel, would cease to be tormented with "iron mills and iron masters," he might have softened his anathema. Smoky and dirty as our iron districts may be, they do not in the present day involve the cutting down of trees for charcoal fuel; and we are so far better off than Evelyn in his Sylvan days. Sussex has no coal, and the iron manufacture left the county when smelting with coal or coke began to supersede smelting with charcoal. Sussex has iron without coal, Durham has coal (nearly) without iron; and the iron-smelting operations are not located in either county.—This gives us a clue to the circumstances which determine the localization of iron works.

The series of iron ores deposited in the Great Exhibition, illustrating the general iron-making resources of the United Kingdom, together with the statistical information concerning them given in the Official Illustrated Catalogue, are full of interest. From thence we learn that the gross annual produce of iron now reaches the enormous quantity of two and a quarter millions of tons; of which South Wales yields about 700,000, Scotland 600,000, Staffordshire and its neighbourhood 600,000, while the remainder is made up of small contributions from various counties. It is not simply the possession of the iron ore which gives us so great advantages in this mighty department of industry; but the coal is so abundant and in such near proximity to the iron, and the lime and claystone necessary to facilitate the smelting are also so amply supplied, that nearly all the iron can be smelted in the district where it is raised, and the expense of bulky carriage is thereby notably lessened. If the iron ore of the coal districts should ever be exhausted, however, we have still a supply in numerous counties belonging to other geological formations. The produce of the British iron manufacture in 1750 was only 30,000 tons; in 1800 it had increased to 180,000; in 1825, 600,000. In 1826 the duties upon the introduction of foreign iron were either removed or rendered nominal; the British iron was left to work its own way, according to its own peculiar properties, while foreign iron became freely obtainable for such purposes as it is most fitted for; and under the influence of these unshackled movements the manufacture has risen in the astonishing way noted above. In the fifty years previous to 1800 it increased six-fold; in the fifty years subsequent to 1800 it increased twelve-fold upon the quantity for that year, or seventy-two fold upon the quantity for 1750! It is in truth among the most astonishing instances of industrial progress which our country exhibits. Taking the Monkland Iron Works, at Calder, as a type of progress generally, we find that in 1805 forging

and rolling only were carried on by the aid of water power; that, in 1825, taking advantage of the excellent iron ore in the neighbourhood, smelting was commenced; and that in 1851 the works comprise nine blast furnaces, at which 60,000 tons of pig-iron and 40,000 tons of malleable iron are produced annually, employing 2500 miners and workmen, and affording school accommodation for 1400 children. The Dowlais Works at Merthyr Tydvil present still more striking proofs of recent advancement.

If we look at the distribution of the mining and smelting operations, as given in the authoritative work above quoted, we find the following facts:—That portion of the South Wales district which has Merthyr Tydvil as its mining metropolis has 12 principal iron works, with 70 furnaces; the Pontypool district has 7 works, with 23 furnaces; the Tredegar district has 10 works, and 50 furnaces; the Neath district has 6 works, and 20 furnaces; the Pentyrch district 5 works, and 11 furnaces; and the Rhuabon district 2 works, and 5 furnaces. There are a few smaller works not here included, and some of the furnaces are out of blast; but without going into particulars in these matters, it may suffice to state that in 1848 the number of iron furnaces in Great Britain was estimated as follows:—

| | |
|---|---|
| England . . . . . . . . | 286 |
| Wales . . . . . . . . . | 207 |
| Scotland . . . . . . . . | 130 |
| | 623 |

The English furnaces are smaller than those of Wales or Scotland, and do not yield so much iron per week.

From the specimens at the Exhibition we may see how numerous are the veins or beds of iron ore, how varied are their appearance, and what strange local names are given to them. We find the *soap vein*, the *black pins*, and the *three-quarter balls;* the *black band*, the *spotted pin*, and the *little pin;* the *big blue*, the *little blue*, and the *lumpy;* the *jenkin pins* and the *penny pieces*, the *blue flats* and the *Bristol diamonds*, the *dog tooth* and the *bacon flitch*, and numerous others, the etymology of which it would be no easy matter to determine. Each of the iron districts has some peculiarity or other, which gives it commercial importance. The Ystalyfera iron is associated with anthracite, which affects the smelting process. The iron ore of the Pentyrch district is principally hæmatite; but as Wales produces every kind of coal, from the bituminous to anthracite, it can readily smelt any kind of ore. Plentiful as the ore is in South Wales, the coal is still more abundant; and that country will probably long continue to be (what it has been for the last few years) the greatest iron-manufacturing district in the world. In the North Wales district both the iron and the coal seams are thin, but good. The Shropshire iron is good, but small in quantity. In Staffordshire, where coal was first used in the smelting of iron in 1619, the iron made is better in quality than that of Wales, and equal in quantity to the Scotch. North Staffordshire produces a much larger quantity of good iron ore than can be smelted with the coal of the same district, and considerable supplies are furnished to other districts. The Yorkshire iron, from Bowling and Low Moor, is especially celebrated for its toughness. The iron ores of the Lake district are very abundant, and the finest in the kingdom; they are eagerly purchased by smelters elsewhere. The Forest of Dean iron ore is especially fitted for the making of tin (or rather tinned iron) plates, and is sent into Wales in large quantities for this purpose. There is a small quantity of ore among the primitive rocks of Devon and Cornwall, better

offered, and having stored his memory with observations on all the combinations, he disappeared from amongst his kind friends as he had appeared, no one knew whence or whither. On his return to England he communicated his voyage and its results to Mr. Knight and another person in the neighbourhood, with whom he was associated, and by whom the necessary buildings were erected and machinery provided. When at length everything was prepared, it was found that the machinery would not act; at all events it did not answer the sole end of its erection—it would not split the bar of iron. Foley disappeared again, and it was concluded that shame and mortification at his failure had driven him away for ever. Not so: again, though somewhat more speedily, he found his way to the Swedish iron works, where he was received most joyfully; and, to make more of their fiddler, he was lodged in the splitting mill itself. Here was the very end and aim of his life attained beyond his utmost hope. He examined the works, and very soon discovered the cause of his failure. He now made drawings or rude tracings; and having abided an ample time to verify his observations and to impress them clearly and vividly on his mind, he made his way to the port, and once more returned to England. This time he was completely successful, and by the results of his experience enriched himself and greatly benefited his countrymen. This" (adds Coleridge) "I hold to be the most extraordinary instance of credible devotion in modern times."

It is no more than just to name the mighty steam-hammer of Nasmyth as one of the means whereby the iron-manufacture has been lately advanced. The irresistible power with which this machine falls upon the glowing masses of iron taken from the furnaces greatly expedites the process of manufacture. On the occasion of the visit made to Birmingham by the Commissioners and Juries of the Great Exhibition, a steam-hammer, at Messrs. Fox and Henderson's establishment, was made to perform its part among the wonders of the day; and we may be pretty certain that the controlling workman, the captain of the hammer, did not fail to exhibit the customary "magique mystérieuse" of that apparatus—the delicate and gentle cracking of a nut by a machine which could almost crush an elephant.

## Modern Experiments, and their Results.

One of the notable improvements introduced in recent years is a combination of many kinds of iron, to ensure the good qualities of each; and another is the admixture of small quantities of other metals. It is supposed that the fluidity of Berlin cast iron, by which the exquisitely delicate ornaments are capable of being produced, is due to the addition of a little arsenic. Manganese is found to give a closeness of grain to iron. Calamine (carbonate of zinc) gives increased malleability to iron; and with certain kinds it produces extraordinary toughness. If calamine be introduced into the iron of a wheel or a rail, it gives toughness and strength; while if antimony be added to the iron of the surface, it imparts a steely hardness; so that qualities can be induced suitable to the different kinds of service which each part is to render. And it is remarkable that these changes are wrought by so small a ratio as 1 per cent. or less of the additional metal. On the other hand, the addition of 1 or 2 per cent. of iron to brass has recently been found to produce a most valuable substitute for bell-metal, gun-metal, and similar compounds; large guns, large screws, propeller vanes, mill brasses, railway bearings, bells, and other articles, are now made of a metal in which copper, zinc, tin, and iron

all take part; the proportions are varied according as toughness, hardness, sonorous power, or susceptibility of receiving a polish, are required; but the combined cheapness and efficiency of the new alloys are now becoming very apparent. There are several bells in the Exhibition of fine tone, made of an iron-alloyed metal, which is only half the price of bell-metal. Returning to iron manufactures, properly so called, it is found that Russian sheet iron (abundant specimens of which are to be seen in the Exhibition) is said to be superior in quality to most produced in England; a peculiar fibrous iron is required; and this fibrous quality is given to the Russian iron (as is supposed) by the presence of a little phosphorus and a little silica in the ore, and by the acquisition of a little carbon from the wood-fuel used in smelting. Such are the discoveries which chemistry is gradually enabling us to make: when we know the causes of difference, we may perchance make those differences disappear at pleasure.

All the world knows that improvements in manufacture tend to economise material. What a capital result it will be, if future experiments should establish the soundness of a principle which was brought before the British Association in 1850, connected with iron furnaces! When iron is smelted in one of the huge blast furnaces of South Wales, four tons weight of gaseous products are sent off into the air for every ton of iron smelted; and these gases carry with them an immense amount of heat. Cannot they be robbed of some of this heat, and the heat be applied to useful purposes? Such is the question now at issue; and Mr. Budd, of the Ystalyfera Iron Works, answers it in the affirmative. He does not allow the heated gases and smoke to escape immediately at the top of the furnace; but he imprisons them in a series of flues, where they are made to heat the air for the hot blast, and to produce the steam which is to impel this hot blast into the furnace; and when these services are rendered, he finally liberates the partially cooled gases. At Dundyvan Works, in Scotland, owing to the enormous quantity of gases which the Scotch coal gives off, we are told that the waste heat from one furnace is actually sufficient to heat the blast, and to raise the steam for three. Mr. Budd even thinks that the waste heat of one Scotch furnace is sufficient not only to heat and supply the blast for that furnace, but to convert the pig-iron into bar-iron in other furnaces; and he seems to entertain no doubt that the ingenuity of our northern neighbours will point out the way to realize these advantages. He states that, even now, upwards of a ton of coals is saved in smelting a ton of iron at Dundyvan, by making the heat of the furnace do more work before being permitted to take its aerial flight; but this is so enormous an amount, that it seems to require verification. Mr. Budd may yet, however, live to see his prediction verified, that "furnace heat will be let out, like mill-power, for burning bricks and other similar purposes."

In these days when the famed *Koh-i-noor* is undergoing criticism alike from all quarters, from the duke to the dustman, and when Spanish jewels and Russian jewels, Indian jewels and Tunisian jewels, are being gazed at by millions of persons, it may be interesting to bear in mind that the diamond has on some occasions been used to convert iron into steel. A somewhat startling and costly experiment this! One of the points of difference between steel and bar-iron is, that the former contains more carbon than the latter; and as the diamond consists of absolutely pure carbon (so far as experiments have hitherto determined) it has been thought worth while to try whether iron can be imbued with the requisite dose of carbon from this source. In the infant stage of the first French revolution, when considerable activity was displayed

among the scientific men of that country, M. Clouet communicated to the National Institute the result of an experiment he made in this direction; and shortly afterwards Guyton Morveau repeated the experiment. A small diamond was selected, and wedged with iron filings into an iron crucible of definite weight, the ratio between the weight of the diamond and that of the iron having been previously determined on; the iron crucible was placed in a second crucible of Hessian earth; this into a third crucible of the same substance (with a layer of siliceous sand between the two); and this into a highly heated furnace. After an hour's heating, the diamond and the iron were found to have disappeared, and a globule of steel to have been formed from them, the weight of which wanted only a few grains of that of the ingredients conjointly. Much controversy arose from this diamond experiment; but the costliness of the precious gem deterred all but two or three persons from repeating it. Mr. Mushet was one who took up the subject eagerly; and he mentions the names of ladies who, taking an interest in the issue of the experiment, transferred some diamonds from their jewel-caskets to the crucible, or at least placed them in his hands for this purpose. To imagine the Koh-i-noor transformed into one component material for a knife, a saw, or a file, might seem a very woeful imagining—a sort of descent from the sublime to the ridiculous; but it would, in fact, elucidate in a significant way the difference between *commercial* value and *chemical* value.

## Recent Applications of Iron in the Arts.

It is in the application of iron to new purposes, or in the extension of its use in others, that the progress of the last half-century has been most marked, and presents the greater number of curious features.

The Birmingham and Hardware departments of the Great Exhibition are truly remarkable manifestations of the extent to which the manufacture of iron and steel is now carried. There is a very world of grates and stoves, dazzlingly bright, displaying their painted china tablets, their ormolu decorations, their encaustic tiles, their foliage and flowers of burnished steel, their Moresque and diapered patterns, their small busts and statuettes, and their delicate white marble. There is the unrivalled cutlery of Sheffield, which some towns in our own country, and some countries abroad, are attempting to imitate, but nowhere with full success; the knives, the razors, the scissors, the weapons, the tools, the needles, the saws, the files—these are the commodities which, not only in Messrs. Rodgers's Sheffield trophy in the English nave (with its half-grain of steel wrought into twelve pairs of scissors), but in the larger and more diversified Sheffield compartment, exemplify the remarkable degree of skill now attained in this department of industry. But if Sheffield attracts us by the brilliancy and excellence of her steel goods, Birmingham tells a still more extraordinary tale concerning the diversity which marks her manufactures in metal. Taking no account (because they do not belong to the subject of this paper) of the varied Birmingham products in copper, zinc, brass, pewter, lead, tin, gold, silver, and other metals, how endless are the forms into which the industry of that town has brought iron and steel! Bedsteads, chain-work, trays, fire furniture and stoves, safes, swords, fire-arms, saucepans, kettles, locks, keys, saddlers' ironmongery, needles, fish-hooks, pens, nails, screws—it is quite in vain to attempt anything like an enumeration. One of the exhibitors has shown how effective is now the process of rolling iron into very thin leaves or sheets; he has produced a book, con-

sisting of forty-four leaves, or eighty-eight pages, of sheet iron, measuring about five inches by three, and so thin that the whole weighs only two and a half ounces. Some of these productions belong especially to Birmingham; some find their head-quarters rather at Wolverhampton, Walsall, Dudley, or others of the remarkable group of towns lying north and west of the "toy shop of Europe." If we speak of locks and keys and safes, a very world of complication lies before us. Though South Staffordshire produces more locks, perhaps, than all the rest of the kingdom together, it is impossible to forget the names of Chubb and Bramah and Mordan, with their *Koh-i-noor* cages, their myrio-permutation keys, their impenetrable locks, and their incombustible safes. Some of the locks and safes are really curious specimens of careful workmanship. There is the *quadruple lock*, consisting of four distinct locks in one, all acted upon at the same time by a single key with four bits. There are locks which show the principle of all the "detectors" patented by Mr. Chubb during the last half-century. Not the least interesting is a collection of lock-makers' tools, and models of the principal apparatus used by those artificers. Nor is it right to forget the challenge of the United States' locksmith, who offers us a store of gold if we can open the casket which contains it. Nay—almost while the present page is being written—this same locksmith has startled his British compeers by picking a lock which they deemed not-to-be picked. It would, indeed, be one of the "Curiosities" of the Great Exhibition, to lead to the development of a new pick-lock theory!

But those details, which relate to clever mechanical working in producing the countless implements of iron at the present day, scarcely come within the scope of this paper. It is the *capability* of being so applied, and the extension of that capability, that we wish here to draw attention to.

The substitution of wrought iron for cast iron in bridges is one of the most notable changes introduced within the last few years. This change, though not originated, was greatly advanced by the experiments relating to the Britannia Tubular Bridge. Those experiments showed that a square form of tube is stronger than a circular or an elliptical form, contrary to what many persons would have supposed; and they also proved, that if the top were corrugated, or else formed of a number of minor tubes, the strength would be greatly increased. This discovery at once suggested a modified form of tubular girder adapted to shorter spans; and we now find such girder-bridges being formed all over England. Mr. Fairbairn, the talented engineer, to whose experiments this advancement is mainly due, says in one of his scientific papers,—"The strength, ductility, and comparative lightness of the material are the important elements of these girders; and their elasticity, retention of form, and other properties, render them infinitely more secure than those composed of cast iron, which, from the brittle nature of the material, and imperfections in the castings, are liable to break without notice, and to which the wrought-iron girder is not subject. This is, however, probably of less importance, as the wrought-iron girder will be found not only cheaper, but (when well constructed, and upon the right principle,) upwards of three times the strength of cast iron." The reader will easily recognise these wrought-iron bridges when they meet his view; they are composed chiefly of plates of iron rivetted to each other, and to thicker pieces of what (from their shape) are called T and L iron.

Of the mighty structure just named, the Britannia Tubular Bridge over the Menai Strait, it presents itself forth to the world as one of the grandest examples of the use of iron. Unlike the principle of Southwark Bridge, in

which cast-iron arches press upon abutments—unlike Telford's Menai Bridge, in which wrought-iron chains support the roadway by suspension—this tubular bridge is formed almost entirely of riveted iron plates, strengthened with T and L irons; it bears its own weight and the weight of the trains which pass upon or through it, by the trustworthiness of its iron plates and rivets. There it hangs, suspended in mid-air at a height of a hundred feet above the water, supported at certain points on lofty towers, but presenting an unsupported length of nearly 500 feet from tower to tower, and comprising in that length not much less than 1500 tons of iron! The planning and execution of such a work would appear terribly daring, were we not made familiar with the experiments and the processes of reasoning whereon the scheme relies. The labours of Mr. Eaton Hodgkinson and Mr. Fairbairn seem very dry and uninteresting to non-professional persons; the strength of materials, the tension of iron, the toughness of tubes, the elasticity of plates, the adhesion of rivets—all sound very mechanical and common-place; yet it is to researches on these and kindred subjects that we owe, not perhaps the simple conception of the tubular bridge, but that trusty reliance which rendered its realization possible.

Iron *lighthouses* take rank among the novelties to which this invaluable metal is now applied. Most readers have some amount of acquaintance with the grand structures at Eddystone, Bell Rock, and Skerryvore; and will readily understand how valuable it would be if such works—or rather works to answer the same object—could be carried to the destined spot piece-meal, but nearly in a finished state, and require only to be put together. Such is one of the many favourable features of the modern iron lighthouses. We believe it was Captain Brown, the engineer of the Brighton Chain Pier, who first made a formal proposition to this effect, in respect to a lighthouse on the Wolf Rock near Land's End; but the first actually made was for Jamaica, in 1842; it consisted chiefly of thick cast-iron plates riveted together. A few others have since been built; and there seems reason to believe that the great success attending the use of wrought-iron sheets in the tubular and girder bridges, will lead to the substitution of this material for cast-iron plates in lighthouses. The iron lighthouse made by Messrs. Fox and Henderson for the East India Company, in 1850, and which is 70 feet high, is principally formed of cast-iron plates; but the lighthouse made by Messrs. Walker in the present year for the American Government, and intended for Florida, consists chiefly of corrugated wrought-iron sheets.

Not the least curious among the iron novelties which our rattling, high-pressure age has produced, are the *iron houses* for California. Brick and mortar are too slow for the gold-diggers, who cannot spare time for such drudgery as building; they are off to the "diggings" by tens of thousands, and wish their dwellings and warehouses to come to them as nearly ready-made as possible. Let us describe one of the many iron houses shipped at Liverpool for St. Francisco. It is 20 feet long, 10 wide, and 9 high to the centre of the arched roof. It is divided internally into two rooms, which have two doors and two windows; and there are ventilating holes with swivel shutters. The walls and roof are of thin iron plates, bolted to T shaped perpendiculars; and there is provision for fastening a wooden lining on the interior. The doors are sheets of iron fixed in wrought-iron frames; and the shutters to the windows are similarly framed. There is an iron stove in each room, fitted both for warmth and for cooking. Now the greatest peculiarity of such a house is, that it may be sent out in pieces, and bolted together

with great expedition. Such a one as is here described weighs about 2½ tons, and costs £60 to £70; and three or four men can put it up and bring it into habitable order in as many days; for every piece is marked, every bolt-hole made, and every bolt and nut provided. In a less ambitious form, outhouses, stables, piggeries, and sheds are made in the same way. Warehouses of considerable dimensions are similarly manufactured. Perhaps one of the largest iron houses yet built was one which Messrs. Bellhouse, of the Eagle Foundry at Manchester, sent to California a year or two ago. It was 27 feet high by 22 wide, two stories in height, and containing eight rooms. Besides the general structural arrangement, there was a wood lining for every room, and a corrugated galvanized iron covering for the exterior. The interior fittings were said to be equal to the average of houses of the same size in England, and yet to be so formed as to be transportable in pieces to their destination.

We must not forget that, if iron has become a substitute for stone and brick in some particulars, it also presents a formidable rivalry in others to *hemp*. Chains for cables, and wires for ropes, are extending most widely in use; they render navigation, mining, and other important avocations, less dangerous and more effective than heretofore.

One of the most notable advancements in the iron manufacture in recent years has been the introduction of *galvanized tinned iron* for an almost innumerable variety of purposes. This consists of iron plate coated with tin, not by the ordinary tin-plate process, but by galvanic deposition. It serves as a substitute for plain iron, for tin-plate, for zinc, and for lead, under certain special circumstances. It is stronger and more durable, for many purposes, than lead or zinc; it is better than plain iron where rust is to be avoided; it is superior to lead and zinc in warm climates, inasmuch as it does not expand and contract to so great a degree; and it is said that the New York Fire Insurance Offices will insure houses at a lower premium if covered with this material than with any other. Withinside a house and without, in vessels and in utensils, in towns and in the country, in manufactures and in domestic economy, we now find this substance employed. Here we meet with galvanized tinned-iron corrugated plates for roofing, and for the sides and doors of "California houses;" in another form there are plain plates for the same purpose; roofs for sheds, roofs and sides for storehouses, and many similar purposes. The roof of the Merchants' Exchange at New York, and that of the new Cathedral at Antigua, have lately been formed of the same material, besides roofs of many buildings in this country. Then, besides the sheet form, there are round and square bars, hoop-iron, wire, tubes and pipes, nails, rivets, bolts, screws—all formed of iron thus protected by the galvano-tin process. There is this advantage also, which is unattainable by the ordinary tin-plate process, that articles can be tinned after they are made in the proper form of iron, provided they are of small dimensions. We ought to have stated above, that the plates are really a combination of *three* metals; for in the first place, a layer of tin is precipitated on the iron plates from a solution of chloride of tin by the galvanic process; and then a layer of zinc is obtained by dipping the sheets into molten zinc. The louvre-boards, or rather louvre-plates, which regulate the ventilation of the Great Industrial building, are formed of the material now under notice.

That many of our novelties and attractions in iron result from improved and improving taste is now pretty evident. The schools of design have not been unfruitful in good results. It is generally admitted, by those who were in a position to form a judgment, that the French Exposition of 1844 exer-

cised a powerful influence on the iron-founders of this country. Whatever may be the value, in a commercial point of view, of the protection which the French Government throws around home manufactures, the beauty of the ornamental iron castings displayed at that Exposition was universally acknowledged. English manufacturers felt that their position was rendered critical; and since that time a marked improvement has been witnessed in one department of manufacture which appeals in a peculiar way to English habits: we allude to stoves, grates, fire-places, and fire furniture. It is unquestionable that England has recently made a great advance in the ornamental details of these productions. The Coalbrook Dale Company's dome, or summer-house, or whatever it may most fittingly be designated, in the nave of the Great Exhibition, is perhaps the most remarkable specimen of casting contributed by any English firm. The dome itself, supported by six rustic-looking columns, from which oak branches and leaves spread out beneath the dome, exhibits a high degree of skill in casting, independent of such merit as it may possess as an artistic design. But we may here ask, as has been asked by others, "why should this casting be *bronzed?*" Many croakers say that we are living in an age of shams; it may be so; but at any rate it is worth while to avoid shams as far as we can. Papier maché is good, and iron is good; but when the first puts on the semblance of solidity which belongs to wood, and the latter the tints which belong to bronze, there is a sort of trickery with which the mind is not quite satisfied—an uttering of (not base coin) but coin which is needlessly ashamed to show its own honest face. Why is not a good iron casting beautiful in an unadorned, unbronzed state? Austria, Berlin, and France, have all sent us castings in which the iron integrity of surface (so to speak) is fully preserved. Our founders can now, if they give fair play to their own skill, produce fine castings either of iron or of bronze; but they surely undervalue their art when they give a bronze cosmetic to true iron.

## Iron Work of the Crystal Palace.

The *Crystal Palace* does not come formally within the scope of this paper; yet it is impossible not to see how strikingly that structure illustrates the rapid advance in the use of iron. The Royal Commissioners, in March, 1850, invited suggestions and plans for an Exhibition building from all quarters; and in the following month no fewer than 233 designs were sent in. England, France, Belgium, Holland, Hanover, Prussia, Hamburgh, Switzerland, Naples—all competed. But all were equally laid aside. "Every possible variety in style, in decoration, material in construction, and system in arrangement, were strenuously recommended by the authors of the respective designs as the great ultimatum sought for;" and yet the Building Committee "arrived at the unanimous conclusion that, able and admirable as many of these designs appeared to be, there was yet no single one so accordant with the peculiar objects in view, either in the principle or detail of its arrangements, as to warrant us in recommending it for adoption." Two of the most remarkable plans sent in were by M. Horeau, of Paris, and Messrs. Turner, of Dublin,—both illustrative in a marked degree of the proposed use of iron. M. Horeau's plan comprised one immense hall or shed, 2000 feet long by about 270 wide, with several small detached buildings. The interior was divided into five avenues by iron columns, which supported arched ribs for the roof. The whole construction was to be free of stone and wood; the foundation of brick, the façade of metal and glass, the floor of asphalte, the roof chiefly of

thick glass; and the whole was to be so formed of repetitions of similar parts, that it could readily be increased or diminished in length. Messrs. Turner's proposed building was about 2000 feet long by 400 wide; the roof in one span rising about 120 feet above the floor; the interior to be formed into three avenues by pillars and semicircular ribs; the general construction of the building to be chiefly in wrought-iron plates; a large amount of glass to be introduced in the iron roof; and a glass dome to surmount the crossing of the nave and transept.

Yet, as we have said, all the plans were rejected; and the Building Committee concocted one of their own, derived from the hints suggested by the others. They endeavoured to combine the following qualities in their building—economy of construction; facilities for the reception, classification, and display of goods; facilities for the circulation of visitors; arrangement for grand points of view; centralization of supervision; and some striking feature to exemplify the present state of the science of construction in this country. The structure was to be supported on iron columns, with a very light exterior, and an iron roof; and at the centre was to be a dome of sheet iron 200 feet in diameter. The Committee explained fully the advantages which seemed to them to attach to such a building; but the public received the plan with very general disfavour; and it will ever remain a curious speculation what could or would have been done if Mr. Paxton's happy idea had not suggested itself.

On the occasion of the well-earned compliment paid to Mr. Fox by a public dinner from his townsmen at Derby, he gave some exceedingly striking illustrations of the difficulties and daring of the project so successfully carried through. On June 22, 1850, Mr. Paxton communicated his remarkable plan to Mr. Fox. On June 28, while the Royal Commissioners were in perplexity concerning the numerous but unpromising building-plans which were before them, Mr. Fox went to Birmingham, to put in hand the drawings and specifications upon which his tender would be based. On July 2 Mr. Cole (one of the Executive Committee) visited Birmingham, with a view of offering any suggestion which might smooth the path for this novel project; and about the same time the addition of the transept (not included in Mr. Paxton's original plan) was suggested by Mr. Henderson, and approved by Mr. Paxton. The *arched* form of the transept roof was, we believe, an afterthought by Mr. Fox himself. Mr. Fox states that just before his tender was sent in he "walked out one evening into Portland Place; and there setting off the 1850 feet upon the pavement, found it the same length within a few yards; and then, considering that the building would be three times the width of that fine street, and the nave as high as the houses on either side, I had presented to my mind a pretty good idea of what we were about to undertake; and I confess that I considered the difficulties to be surmounted in constructing that great palace were of no ordinary kind; but feeling confident that with great energy, good arrangements, and a hearty co-operation on the part of our extensive and well-disciplined staff, it might be accomplished, and that upon it depended in all probability the success of the Exhibition, we determined to undertake the responsibility; and the opening on the 1st May has proved the correctness of our conclusions." The tender was sent in on the 10th of July; the arched roof of the transept, as an additional feature, was suggested to the Commissioners on the 15th; and the tender was accepted on the 26th, subject to the contingency of the Commissioners obtaining a royal charter. It affords a proof of the abiding reliance which all the

felt in the soundness of the great scheme, that not only did Messrs. Fox and Henderson undertake the contract before the Commissioners were in a position to give legal certainty to it, but they actually incurred liabilities to the extent of 50,000*l.* under the same uncertainty; the tender was accepted on July 26, but many months elapsed before the Commissioners obtained their charter, without which the contract was not a legally binding one.

The tender having been accepted, the planning of all the minor details, and the preparation of the working drawings, became the next stage in the arduous undertaking. "The drawings occupied me," says Mr. Fox, "about eighteen hours each day for seven weeks; and as they came from my hand, Mr. Henderson immediately prepared the iron work and other materials required in the construction of the building." As the girders and trusses were made, they were subjected to a test four times greater than their strength would ever have to bear in practice, so as to dissipate all anxiety on this point. On the 26th of September the first iron column was fixed in its place. "From this time," Mr. Fox adds, "I took the general management of the building under my charge, and spent all my time upon the works, feeling that, unless the same person who had made the drawings was also present to assign to each part, as it arrived upon the ground, its proper position in the structure, it would be impossible to finish the building in time to ensure the opening on the 1st of May." The contractors speedily got the operation into such good train, that they were able each *day* to fix as much iron work as would be required for the roofs of the Derby station, one of the largest railway stations in the kingdom.

The iron-work of this building, this curiosity of industry and daring enterprise—this "huge mass of transparency," as it has been designated—may be briefly described in the following words.

The building, as almost every one is now aware, is about 1851 feet long by 408 wide. There is, besides this, an additional projecting portion on the north side, 936 feet long by 48 wide. Very near the centre of the length, at a point determined by the presence of certain large trees, the building is crossed by a vaulted transept, 408 feet long, 72 wide, and 108 high; and other trees in various parts of the area have determined the formation of five open courts. The total area of the building is about *six times* that of St. Paul's Cathedral!

It is a notable feature in the building, that 24 feet is a unit of horizontal measurement throughout every part. All the various avenues which lead east and west through the structure are 24, 48, or 72 feet in width; the transept is 72 feet wide; the galleries are 24 feet wide; the refreshment courts are 48 feet wide; the various "courts" which form such admirable exhibition rooms, such as the Mediæval, the Carriage, the Sheffield, the Birmingham, the Tunisian Courts, &c., are 48 feet wide; the external partitioning presents 8-feet compartments; the elegant iron railing which surrounds the building has its standards or posts 8 feet apart; the ridge-and-furrow roof has the ridges 8 feet apart. All these numbers are either multiples or sub-multiples of 24; and it has been found that the calculations necessary in adjusting the materials have been greatly facilitated by this simplicity of ratio. This symmetry is obtained by placing all the hollow iron columns which form the skeleton of the building at distances of 24 feet apart, except in those places where the wider avenues or courts require a space of 48 or 72 feet. For the most part, the building is seen to be divided into bays or compartments, exactly 24 feet square.

The lower columns are 19 feet high; the upper 17; and there are connecting pieces, 3 feet high, from the lower to the higher ranges. These connecting pieces furnish the means for fixing the upper columns to the lower, and also for fixing the girders which stretch across from column to column. Some of the girders are cast iron, some wrought; but all have the same pattern or design, which combines strength with lightness. The girders, in their turn, support the galleries, which extend east and west in four parallel lines, and north and south in ten subsidiary or partial lines. The stories of columns, one, two, or three in number, determine the height of the various parts of the building. There is, for example, a strip 72 feet (3 bays) wide, on the southern side of the building, which is only one column in height; then there is another strip, also of 72 feet, two columns in height; then the magnificent central compartment, 120 feet (5 bays) wide, three columns in height; the two northern compartments of 72 feet each, similar to the southern, are one and two columns in height respectively. The extra building on the extreme north is also one column in height. These various heights, including the connecting pieces, amount to about 24, 44, and 64 feet.

The *roof-girders* are of cast iron, except those which exceed 24 feet in length; each girder weighs 12 cwts., and has been tested to the extent of nine tons—much beyond what it will ever have to bear. They present a light, open, trellis-like aspect, which adds much to the graceful elegance of the interior of the building. Those roof-girders, or trusses, which are 48 and 72 feet long, to span the wider avenues, are formed of wrought iron; they consist of iron bars, riveted at intervals of eight feet to upright standards; some of the diagonals are of iron, to give the requisite strength; while the others are of wood, to give uniformity of appearance. The girders or trusses of 72 feet length have a *camber* or rise of about 10 inches in the centre, which imparts additional strength. The 72 and 48 feet trusses weigh respectively 35 and 13 cwts. There are four of the long trusses beneath the lead flats at the sides of the transept, which, on account of the great weight to be borne, are deeper and heavier than the rest; two of them weigh 120 cwts. and the others 160 cwts. each. All these trusses (*i. e.* girders above 24 feet in length), about 370 in number, were built together on the ground; the various bars being joined together with red-hot rivets, of which 25,000 were used. The rivet-holes were made, some by boring and some by punching—especially the latter; one of the powerful punching machines employed at the works was capable of punching three thousand holes in a day through thick iron plate.

The columns—those lightsome vertical supports which assist in giving such a beautiful net-work perspective to the interior—have a three-fold office; they bear up the galleries, they bear up the roof, and they form channels for rain water. They are all of the same diameter externally, but the thickness of metal varies according to the strength required. The contour—four curves separated by four flat surfaces—was suggested by Mr. Barry, the architect, and has been universally admired. The two ends of each column have projections called *snugs*, which afford means for riveting the column above and below. There are the enormous number of 3300 of these columns, varying from 17 to 19 feet in height.

The *connecting pieces* and the *base pieces*, also of iron, afford the means for fixing the columns firmly in the desired positions. The columns in the different stories do not rest upon each other, end to end; they are separated by a space of about 3 feet, which is occupied by a hollow connecting piece of cast iron. The connecting piece has flanges and rivet-holes, which enable it to be firmly fastened to the column beneath, the column above, and the girders at

the sides. No part of the structure required more careful workmanship than this, as strength, perpendicularity, and absence of leakage were necessary conditions. The base pieces lie beneath the lowest range of columns. Each base piece consists of a vertical hollow shaft, a broad horizontal bed plate at the bottom, strengthening shoulders rising from the bed plate, and side sockets for joining to the horizontal water pipes. These base pieces, of which there are 1074, are bedded very firmly in the ground, as the whole weight of the building rests upon them.

The *gallery girders* are much more numerous than the roof girders before described; they are 2150 in number, and are of cast iron, all 24 feet in length by 3 feet in depth. They not only support the galleries, but stretch across the narrower avenues of the building, from column to column, where a binding strength is required. They have projections at their ends which fit into recesses in the connecting pieces, and by which they are secured. Every girder, before being used, was tested by a powerful hydraulic machine; it was calculated that the greatest weight each girder would have to bear is 7½ tons; but every girder was tested to 15 tons, and it was found that 30 tons was insufficient to break one of them.

The galleries, the transept, the staircases, the flooring, and the exterior, contain too little iron to call for notice in this place. There are some horizontal iron pipes, however, which play an important part in the building. The sixteen or eighteen acres of roofing present an enormous surface for rain-fall, and it is most essential that the water should have easy channels along which to find its way. It first falls on the sloping glass, then along the Paxton gutters, then in a channel along the tops of the roof trusses, then down the hollow columns; and when it reaches the base pieces at the foot of the columns, other provision has to be made for it. Iron pipes, 6 inches in diameter, are fixed into the sockets of the base pieces, and extend in parallel lines east and west; they discharge the water into large drains, which eventually convey it to the sewer.

The whole weight of iron work in the building is said to be about 4000 tons. Two of the mightiest works of our age present the following comparison:—

| | | | |
|---|---|---|---|
| Crystal Palace, | 1851 feet long, | 4,000 tons of iron work. | |
| Britannia Bridge, | 1513 ,, | 10,000 ,, | ,, |

There are, perhaps, no two modern buildings in the country which present greater contrasts than these astonishing structures—the one to contain (at most) two railway trains at a time; the other to contain millions' worth of the world's industry and tens of thousands of the world's people—the one destined, probably, to endure for ages; the other yet in doubt whether its life may not be a very brief one—the one stiff and inelegant; the other full of graceful lines, tints, and combinations—the one so costly as to impoverish its owners; the other so happily circumstanced as to pay for itself in a short period of three or four months—the one occupying several years in construction; the other not much more than as many months. They resemble each other, however, in this (and the resemblance is a marked feature in our age), that iron instead of stone forms the main material, and that engineers instead of architects have conceived and worked out the plans.

## Foreign Iron, at the Great Exhibition.

The production and application of iron in foreign States, whether illustrated or not at the Great Industrial Gathering of Nations, are not less full of curious and instructive features than those of our own country.

It is pleasant to see how careful our foreign neighbours have been to carry out, to the best of their means under the circumstances, the behests of the Royal Commissioners concerning classification. Each country, with a few exceptions, has collected specimens of its raw materials of manufacture; and among such specimens iron and its ores do not fail to find a place. The *United States* have many fine specimens of iron ore, especially from the busy Ohio district. There is also manufactured iron presented to our notice, in the forms of plate, sheet, bar, rod, wire, nails, &c. The gigantic empire of *Russia* is peculiarly circumstanced in respect to these matters. It has been well observed that "the want of a great middle class, and of self-dependent (and therefore independent) working classes, causes the arts and manufactures to be dependent on imperial ukases and the encouragement and example of the government officers, or else upon the magnates, whose command of labour enables them to undertake new operations on a large scale." Hence we find that a large proportion of the specimens at the Great Exhibition have been sent from some of the imperial establishments; others from the great princes of the empire. Prince Demidoff has sent various specimens of iron in the raw and the reduced states; the collection of iron plates, bolts, bars, rods, &c., is by no means insignificant, considering the unfavourable circumstances attending the transhipment of heavy goods from an ice-bound country. The *Zollverein*—that mysterious-looking word, which puzzles so many visitors, and which the Executive would do well to elucidate by a subsidiary inscription—presents us with a goodly collection of the iron and steel which Prussia, Saxony, and the other German States can produce. The Harz Mountains, many places in Rhenish Prussia, and many others in various parts of the Zollverein or "Customs Union" territory of Germany, produce excellent iron, which is smelted and worked up at various establishments; while Solingen has acquired the name of the Sheffield of Germany. We find specimens of the ore and the metallic iron; sheets, and other partially manufactured forms of iron; neat and useful iron castings from the Harz establishments; a most interesting series of specimens which show all the stages of progress from crude ore to highly-polished steel; a varied assemblage of cheap every-day iron and steel tools and goods, such as screws, nails, files, saws, locks, keys, bolts, chains, axes, hatchets, skates, swords, rat-traps, hand-mills, and all the usual cutlery articles; and the clean and wholesome enamelled iron ware, so valuable an adjunct in domestic cookery.

But the *Berlin* cast-iron ornaments—did the art of working in this metal ever reach a higher pitch than in the delicate productions thus designated? It is scarcely credible that the exquisite brooches, buckles, and other specimens, deposited in the northern half of the Zollverein compartment, can be made of such a rough material; yet such is the case. The delicate gold and silver threads of the *filagree* works of the middle ages hardly excel them in minute beauty. *Austria* is not exceeded by any foreign country in the specimens of iron which she has contributed to the Great Exhibition. When we consider how many kingdoms and states are included under that almost misapplied word Austria, we need not wonder that some among them should yield fine iron ores and creditable iron manufactures: but it could scarcely have been expected that such unity of feeling would have been displayed as this unique Exhibition indicates. The iron ores of different parts of the empire are not only of fine quality, but in great abundance; and the art of smelting (aided by the plentiful supply of charcoal timber as fuel) is scarcely excelled in any part of Europe. The specimens of iron plates, sheets,

bars, rods, wire, &c., are numerous and good. It is worth while, too, to study a little closely the fine castings from the Metternich Iron Works, one of the Bohemian establishments; the tall German stoves, decorated with delicate and well-formed statuettes, the full-sized cast of the Crucifixion, as well as other castings of a varied kind, exhibit a high degree of merit. Among the cutlery of Austria, we have an abundance of scythes and sickles, of which it is said no fewer than 7,000,000 are manufactured annually in Austria Proper, and exported thence to various parts of the world. *Belgium* has not failed to show, by her contributions, that the iron of the Liége district is well smelted, and well worked up into countless articles of daily use and ornament. That the iron smelting arrangements of *France* are not very extensive is not her fault; nature has not gifted her so bountifully as many neighbouring countries with the crude iron; and the Great Exhibition clearly shows that, in other metals, she excels her productions in iron. In respect to *Spain*, it is vexing to know that such fine iron as her mountains contain is of little value to her, on account of the wretched state of the country in respect to roads and canals, which renders it so difficult to transmit heavy produce from one part of the country to another; a few specimens of Spanish iron ore have been sent to the World's Fair; and those who know what a reputation Toledo sword-blades once had, can only regret that we have so few opportunities of judging the qualities of Spanish steel.

There is one country, *Sweden*, from whom it was especially important that we should receive good specimens of iron and its ores; and it is gratifying to know that such has been the case. These specimens are by far the most to be prized among the few from that country. Many users of English cutlery are not aware that the best varieties are made from Swedish iron, which—from some cause not yet well understood—produces better steel than any English iron. Among the Swedish specimens are included everything which can illustrate the mining characteristics of the ore, such as bits of the surrounding rock, the rock intermixed with ore, the several kinds of ore, analyses of the metallic contents of these several ores, &c. There are also plates, tubes, files, and other articles manufactured in Sweden, showing that, though the material is of the best quality, the manufacture is not of a very high order.

## Commercial Value of Iron, in Central Europe.

The dainty little cast-iron ornaments of Berlin, alluded to above, are associated in a peculiar way with the all-important struggle between Napoleon and Prussia. There is something very touching in the narrative of the growth of this branch of industry. So overwhelming was the force which the ambitious conqueror was able to bring against Prussia, that the services of all were energetically called for against the common enemy; the country needed the strong arms of her sons, and the silver and gold of those who had silver and gold to give. The matrons and maidens of high birth or good fortune sent their trinkets and jewels to the royal treasury to recruit the exhausted exchequer; and, in return for them, they received rings, crosses, and other ornaments in cast iron, which bore the inscription *Ich gab Gold um Eisen*, "I gave gold for iron." These humble ornaments were at the time very highly prized from the circumstances attending their acquisition; and even at the present day the families of the original possessors value and preserve them as honourable relics, as badges of a true nobility—the nobility of feeling. The sudden

elevation of such ornaments into distinction gave a great impetus to everything connected with their manufacture. The castings were not confined to mere trinkets, but comprised busts, bas-reliefs, monumental slabs, and other works of art. Some persons attribute the unequalled excellence of these castings to the fine quality of the Silesian iron; some to the carefully-made mixture of sand and clay of which the moulds are formed; some to the skill displayed in the casting process; but it is probable that many causes contribute to the result.

Dr. Friedenberg, in his German translation of Babbage's *Economy of Machinery and Manufactures*, gives some curious information concerning the Berlin castings. Such are the fineness and delicacy of the separate arabesques, rosettes, medallions, &c., of which the larger ornaments are composed, that it sometimes requires nearly 10,000 of them to make a lb. weight. The gray iron from which they are made may be taken as being worth about 6*s.* per cwt.; and the following table, drawn up from the price-list of a Berlin manufacturer a few years ago, will show to what an almost incredible height this value per cwt. is increased:—

| Articles. | Number to 1 cwt. | Price, each. *s.* | *d.* | Price per cwt. £ |
|---|---|---|---|---|
| Buckles, $3\frac{1}{2}$ inches long by $2\frac{1}{2}$ broad . . . | 2,640 | 2 | 6 | 330 |
| Neck-chains, 18 inches long by 1 broad, in 40 pieces . . . . . . . . . . . . . . | 2,310 | 6 | 0 | 693 |
| Bracelets, 7 inches long by 2 broad, in 72 pieces . . . . . . . . . . . . . . | 2,090 pairs | 8 | 6 | 880 |
| Diadems, $7\frac{1}{2}$ inches high by $5\frac{1}{4}$ broad. . . | 1,100 | 16 | 6 | 907 |
| Sevigné points, $2\frac{1}{2}$ inches long by $1\frac{1}{2}$ broad . | 9,020 | 4 | 6 | 2029 |
| Sevigné earrings, 3 inches long by $\frac{7}{8}$ broad, in 24 pieces . . . . . . . . . . . . | 10,450 pairs | 5 | 3 | 2743 |
| Shirt buttons . . . . . . . . . . . . . | 88,440 | 0 | 8 | 2948 |

We here find that iron in the form of shirt buttons commanded a market at a price nearly 10,000 times as great as that which it sold for as gray iron! And about the year 1820, when the fashion was at its height, the value was still greater; for these iron ornaments then sold for nearly their weight in gold. The great saleable value of these productions has led to a result similar to that which so many other branches of industry exhibit: obscure manufacturers make moulds from the casts which others had been at the expense of designing and modelling, and produce inferior and cheap specimens from these moulds. The *real* Berlin castings, worthy of the name (such, we may presume, as those which grace the Great Exhibition), must always command a high price, if sold at all, from the extraordinary care required in their production.

It would be instructive, in an economical point of view, if the *prices* of useful articles, as displayed at the Great Exhibition, could be compared at leisure. There are so many elements which combine to make up mercantile value, that it is difficult to estimate them singly; but their resultant—their combined effect—is shown in the price at which the dealer is willing to part with his merchandize. We may be well assured that it is worth while for a manufacturer in one country to be fully informed of these particulars in respect

to foreign countries. If he *can* equal his neighbours, a close comparison and study will enable him to determine how to do so; if he can *not* equal them, a knowledge of the reasons will save him from much fruitless outlay. It is in this, as in so many other respects, that the Great Exhibition will render service. Probably the Commissioners exercised a wise discretion in forbidding the price-ticketing of the exhibited specimens; but we shall gradually acquire information on those points in other ways. If we take up, for example, the Official Priced Catalogue of the Saxon section, we find English sums of money quoted opposite the names of the chief articles displayed; they are the prices, we presume, at which the Saxon agents in this country would be empowered to sell such commodities. Here we find (confining ourselves to the immediate subject of this paper) tinned-iron saucepans and cooking vessels in considerable numbers; there are Saxon vessels, Bavarian pots, coffee-pots, stew-pans, frying-pans, &c. A half-litre cooking-pot is marked at $3\frac{1}{2}d.$; a litre coffee-pot, $4\frac{4}{5}d.$; a four-litre stew-pan, with handle and lid, $16\frac{1}{2}d.$; a frying-pan, $23d.$; and so on. The vessels are tinned after the sheet-iron has been brought into shape; and their capacity is estimated by the *litre*, equal to about $1\frac{3}{4}$ pints English. Now here is a case for those conversant with retail ironmongery. Are these articles well made, and are they dearer or cheaper than similar articles in England? Be the answer what it may, it is certain to render service in some way or other. Then we find iron spoons at $2d.$ per half-dozen. The clasp-knives sent from the same country are of the better and more ornamental kind; they vary from $2s.$ to $12s.$ each, according to the number of blades and the degree of finish; but it would be more interesting to know how much the Saxon peasants give for their rough homely knives.

The *Zollverein* Catalogue presents, in like manner, the means for instituting comparisons between ourselves and the busy states of Northern Germany. Among the entries are case-hardened iron rollers, at 20 dollars per centner; chisels as low as 15 groschen per dozen; files and rasps, 11; scissors, 15; butter-knives, 38; plane-irons, 27 groschen per dozen; up to much higher prices according to size and quality. We may here state that the Prussian dollar or thaler is worth about three shillings English, that there are twenty groschen in the dollar, and that the Prussian centner equals about 110 lbs. It is obvious that a comparison between the prices above named, and those charged by our own manufacturers, can be usefully made by those only who are practically concerned in these matters. The delicate little Berlin castings, such as brooches, &c., are priced from a groschen to a dollar each; but it would be vain to compare these with English prices until England produces something equal, which she assuredly never yet has done.

From the lately published Official *Austrian* Catalogue of the Great Exhibition, we gather some valuable information concerning the iron mining of that extensive empire. There were produced in the year 1848, about 3,200,000 cwts. of pig-iron, of which Styria and Hungary contributed together about one-half; of cast-iron there was about 450,000 cwts., all from Bohemia, Moravia, and Silesia. It appears, therefore, that the kingdoms or provinces in which the iron is mined and smelted in greatest abundance, are not those which take the lead in producing iron castings. The pig-iron is smelted in about 260 furnaces, and melted for castings in about 60 cupola and reverberating furnaces. From the pig-iron, besides a portion converted into castings, about 300,000 cwts. of steel are made annually. Both in malleable iron and cast iron, Austria exports more than she imports, a sufficient proof that she is favourably circumstanced in respect to this really important element of national wealth. The number

of persons employed in the Austrian dominions in 1848, in raising iron ore, smelting, casting, forging, steel making, and manufacturing commodities in iron and steel, was about 150,000; and the value of the commodities so produced was about 70,000,000 florins (about £7,000,000). It may here be stated, that the cwt. spoken of is the Austrian *centner*, equal to about 123 lbs. English. The following details are interesting, for they relate to the productive industry of a country with which we have hitherto been too little acquainted:—"Of the different branches of this (the iron) department of manufacture, those that are conducted on a large scale seem to deserve most attention; among these, the first that presents itself to our notice is the manufacture of scythes, sickles, and chaff cutters. The produce of 179 scythe factories was 4,000,000 scythes, 1,600,000 sickles, and 90,000 chaff cutters, valued at 5,000,000 florins; these articles, on account of their excellent quality, have found their way into all parts of the world. The manufacture of pans, boilers, and kettles, carried on in 50 establishments, turns out 25,000 cwt. of articles, valued at 675,000 florins. The manufacture of wire is of greater importance, and is carried on at 100 factories, producing about 80,000 cwt., value 1,364,000 florins. The manufacture of nails is also very extensively carried on, and amounts to 50,000 cwt., valued at 970,000 florins. The smaller workshops appropriated to other manufactures in iron, produce files, knives, hatchets, shovels, sword blades, gun barrels, and various other articles, to the value of 4,800,000 florins; they give employment to more than 60,000 persons (of whom about 15,000 are masters), and support 150,000 individuals, including the members of the families of those employed."

It might at first seem strange that, while England can produce every kind of iron implements at extremely low prices, Austria should be able to export by millions the scythes, and sickles, and reaping hooks needed by the farmer. But in this, as in many other cases, we must look at the quality of the ore met with, and the means for obtaining iron from the ore. Now, in Styria (one of the component members of the Austrian Empire) there is a peculiar and very abundant kind of spathic iron ore, a semi-crystalline carbonate of the metal; and it is proved that the steel made from the iron of this ore is excellently suited for the kind of services required in the cutlery implements here named.

### Economical Peculiarities in Germany and America.

The rise of the iron manufacture in Rhenish Prussia is becoming astonishingly rapid. Smelting and forging establishments on a very large scale are multiplying fast. Let us take Mr. Banfield's account of a visit which he paid to the iron-works of Messrs. Haniel, at Oberhausen, a few years ago. Near the works are cottages which the firm had built for the workmen; the buildings are well planned and constructed, and are made over to the workmen at prime cost, to be paid for by small deductions from their wages during a series of years; this comprises the best elements of a Building Society, without its defects. In respect to the value of the land near the works, Mr. Banfield makes a striking remark: "It is, perhaps, not too much to say, that every fresh pair of rolls (rollers for making bar iron) erected at Oberhausen, would add the value of a dollar an acre to every estate whose owner had sense enough to draw his profit from it."—(*Industry of the Rhine.*) The Oberhausen works stand on about as much ground as the Low Moor works, in Yorkshire. The central part is occupied by the rolling mill, round which

nearly forty puddling furnaces are ranged, each with its hammer and pair of rolls. Nasmyth's steam hammer was introduced in these works almost as soon as in England. Workmen of many different nations are employed, and on this point Mr. Banfield makes the following observations:—"When the drill is good, there is sometimes an advantage in this; for the national rivalry is awakened, and urges the men to do their best for the sake of the good name of their country as well as of their own. The high wages paid to puddlers and rollers, and the present necessity for employing strangers, owing to the suddenness of the demand that grew out of the spread of railways, is a strong incentive to the Germans, who make great exertions to fit themselves to the task, and of course now succeed. The only superiority in the strange workmen lies in their having seen large works in England or in Belgium, and knowing the methods used in them. But now that mills are erecting all over Germany on quite as large a scale as the English, there will be a school to train them in at home. We could not help thinking, on viewing the scene, that some advantage might be derived from that kind of masonic hospitality which prevailed in the Middle Ages, and which encouraged men to visit other countries, with their trade as a passport and letter of credit, which ensured them a good reception wherever they went. It is, perhaps, natural that strange workmen in Germany should be well received where they appear as teachers; but it is creditable to every country in which hospitality is dictated by good feeling." A singular fact met Mr. Banfield's view: a water-mill was built, in the infancy of the works, to give motive power to the machinery, but it is now wholly employed in grinding corn for the 1000 persons employed in the establishment. The proprietors have built a refectory, where they serve such of the workpeople as are willing to avail themselves of the accommodation with provisions, at a low price, on a system which keeps clear of the knavery of our truck-system. It is another good feature at these works, that all the workpeople deposit something weekly in a Savings Bank, as a reserve for times of difficulty.

As a contrast to the fine arrangement of the establishment just noticed, we may glance at Mr. Banfield's description of a mining and smelting work near Siegen, managed on what we may call the peasant-proprietor system. The Eisenzeche Mine is situated in a valley; its adit, which runs upon the vein, is about an English mile in length. There is no provision for horse-power, but a tram-road is used to run out the stuff. Around the entrance heaps of ore, of two tons each, lie nicely piled, each with a wooden cross stuck in it, marked with some kind of miners' heraldry—such as a ship, a tree, or an initial, to indicate that it belongs to one particular shareholder in the mine. The mine belongs altogether to small miners, and is worked by themselves, under the direction of mining officers. From the piece-meal and primitive mode in which the operations are conducted, the profits of the miners amount to no more than very moderate wages. In a smelting work not far from the mine, there is a furnace in the middle of a large casting house, which affords shelter to the numerous smelters and their gossiping neighbours. As the result of a timid caution lest the mines should be too soon exhausted of their treasures, each smelt-work is limited to a certain number of days in each week; and each miner attends to smelt his own little store on the prescribed days. Nothing can be more opposed to the organized system of a modern establishment than the proceedings of these smelters—these children of antiquated usages. Each man has

his own small shed full of ore, and another shed full of charcoal; and all these little erections are huddled irregularly round the furnace. Here he sits, unless frozen out by the cold of winter, breaking up his ore with a hammer; his never-failing pipe (to light which necessitates frequent trips to the furnace and gives an opportunity for gossip) hangs to his lips. When his turn comes, he wheels his ore to the furnace mouth under the superintendence of the *Hüttenmeister*, or furnace master, and contributes his quota of charcoal and broken ore to the fiery heap. He claims a portion of the smelted contents of the furnace, and assists in bringing it into saleable form. "The peasant owners (of the land around Siegen) are also shareholders in mines, and in the forests around, which supply the charcoal consumed. They manage to divide their time between the mine, the forest, the furnace, and their land, in such a manner as to be unceasingly employed, and they calculate closely enough in isolated speculations; but the grand calculation of all, the benefit conferred by division of labour, is unknown to this community." One of the unfavourable consequences of this patch-work system is, that each small speculation has its own shafts, adits, galleries, &c., without any relation to those of its neighbours, so that much more digging, dragging, and lifting are bestowed, than the extent of the mineral veins renders necessary.

There was a paper communicated to the *Franklin Journal* a year or two ago which is worthy of notice as showing how apparently minute are the circumstances which determine the power of one country to equal or excel another in exporting manufactured goods. The subject relates to iron; and the writer, a Mr. H. Fairbairn, laments the inability of the United States to keep out English iron, notwithstanding the abundance of iron and coal in that wide-spreading region. The pith of his argument is found in the fact, as stated by him, that the smelting works have been injudiciously built at a distance from the great coal-deposits; so that the coal, cheap at the pit's mouth, becomes costly by the time it has reached the furnace mouth; while a "manufacturer of railroad iron in Wales smelts his pig-iron from the ore, puddles and refines the iron into bars, and mills the bars into railing iron—all with the coals dug at the door of his establishment, with the same steam-engine throughout all the processes (perhaps?), by the same supervision, in a shorter space of time." The result was that, in 1849, English railway iron undersold Pennsylvania iron in Pennsylvania itself. But Mr. Fairbairn thinks that this state of things must pass away, if large smelting works were established in the iron and coal district of Pottsville. "From hard siliceous iron ore only a tough, unmalleable, and cold short iron can be made; and the richer hematite ores are indispensable for admixture with the siliceous ores of Pottsville or of Wales. But in Wales these hematite ores can only be obtained from the north of England, and their expense is so great, that this circumstance now threatens the most serious consequences to the trade of Wales. A ton of hematite ore cannot be brought from Ulverstone to Merthyr Twydwell (Tydvil) at a cost of less than 28*s*. per ton; and yet so important is it to have hematite for admixture with the native ores, that the character of the Welsh railway iron is rapidly degenerating in foreign markets, by reason of the impossibility of affording the importation of these ores at the prices for railroad which can only now be obtained, in consequence of the low prices established in the Clyde." Starting from these two data—that the Welsh iron masters cannot pay for hematite if they sell at low prices, and that their iron will lose its saleable qualities if it do *not* contain hematite, Mr. Fairbairn draws favour-

able auguries for his own country, in the circumstance that hematite is to be met with at no great distance from the coal and iron district around Pottsville; and that, if smelting works were established there, Pennsylvania might defy both Wales and Scotland.

Whether the above train of reasoning be sound or not, it is quite demonstrable that the proximity of a coal-mine to a smelt-work is of great importance to the latter. Mr. Fairbairn well illustrates this point, which forms part of the commercial philosophy of manufactures, in the following remarks:—"Only the finer branches of iron manufacture can exist in cities, or in localities distant from the supplies of coal. In Liverpool there are large foundries, and a great steam-engine business is carried on; but the heavier parts of the engines are brought from places in the Midland Counties, and only the finer parts of the work are manufactured in Liverpool; whilst in London, though myriads of people are employed in manufactures of which iron is the raw material, yet it [the employment] is in cutlery, in fine castings, and the thousand divisions of business in which the raw material does not enter so largely into the manufactured articles as does the skill of the artisan, the presence of the metropolitan market, the fashion, foreign demand, and many other considerations which favour manufacturers in cities and towns. But a bar of railway iron was never made in Liverpool or in London, and none can be profitably made in Philadelphia, which is the Liverpool of the United States. Foundries, cutleries, and other skilled iron manufactures of endless varieties, might be established with the greatest advantage in Philadelphia; but the pig-iron, the bar-iron, railway bars, beams for steam-engines, and all other heavy and comparatively cheap iron and iron manufactures, only can be furnished from the places where fuel is to be obtained at the lowest rates."

The few, brief, scattered notices of iron and the iron manufacture in foreign countries which have found a place in the present sheet—trifling as they may be singly—all tend to illustrate the value which we ought to place on a knowledge of the proceedings of industry in other lands besides our own; such knowledge may be made up of "curiosities," but it is not less knowledge on that account. And if the Royal Commissioners should carry out the proposed plan of making a permanent collection of specimens—tiny bits for the great assemblage—we may hope that iron, foreign as well as British, rough ore as well as polished bars, will not be forgotten.

# WOOD AND ITS APPLICATIONS.

There is a battle going on among the materials of manufactures. From time to time the old familiar products of Nature's work have to contend against new aspirants for public favour; and the new comer occasionally bears off the palm. Sometimes metal has to yield up one of its positions, which is taken possession of by wood; and wood, on the other hand, has, in no small number of cases, been obliged to yield to metal. Then, again, although it is said there is "nothing like leather," yet the gutta-percha dealers confidently dispute this maxim; and the workers in papier-maché no less resolutely enter the domain of the workers in wood. Staffordshire claims for its "Parian" clay statuettes a place by the side of those made in Parian marble; and the cement artificers will not admit that marble and stone are more beautiful or more durable than the produce of their labours.

But such is the right path towards excellence. These unwearied trials develope properties—often beautiful as useful—in natural substances, which would remain unknown if the old prescriptive notions were too closely adhered to. It is true that the new attempts occasionally fail, and that the unsuccessful experimenter is made to smart for the failure; it is true also that offences against good taste sometimes mark the novelties, by a certain incongruity between the material employed and the purpose of the article produced; but these matters always adjust themselves after a time—society prunes off the redundancies, and avails itself of whatever amount of good may result from the search after what is new.

*Wood* is among the natural products which have been singularly exposed to these industrial contests (if they may be so termed). As a material for building, it supersedes all others in an early stage of society; but it gives way to brick and stone as forests become cleared. As a fuel, it is every year yielding more and more to coal. As a material for engineering and large works of construction, its use is now most sensibly lessened in favour of that of iron. As a material for decorative furniture, or for fine-art productions, it has to contend against the rivalry of papier-maché, of cement composition, of japanned iron, of stamped leather, of carton pierre, of gutta-percha.

Yet wood is more abundantly used than at any former period, and for more diverse purposes. If any circumstance shakes its supremacy in one quarter, it speedily finds room for exercise in another. There is a natural and deeply-seated cause for this: if the worker in wood is disturbed in his vocations by competition from a worker in another material, he has abundant reason for trying to strengthen his position in other directions; and his ingenuity, sharpened by self-interest, points out the way.

## Timber of all Nations: Great Exhibition.

The first half of the present century has witnessed many of the revolutions noticed above. It has seen the substitution of other materials for wood in many manufactures; but, on the other hand, it has been marked by the appli-

cation, to useful purposes, of kinds of wood before almost unknown; and especially has it been characterised by a great extension due to the use of steam-worked machinery.

Let us say a few words concerning timber itself, before speaking of the "curiosities" in its application.

Mr. Holtzapffel, in his elaborate work on 'Turning,' gives a very minute description and classification of the various kinds of wood used in the Arts. He first points out the well-known structural difference between *exogens* and *endogens*, which leads to a separation of all kinds of trees into two great groups; all the *true woods* (as they are sometimes termed) are exogens; whereas the endogens include the grasses, bamboos, palms, &c. In the countries where bamboos and palms are indigenous, the smaller stems are used as tubes for the conveyance of water, and the larger pieces as joists, &c. In the larger kinds of palm, the fibres appear like streaks or wires embedded in a substance similar to cement or pith. The natives of the Isthmus of Darien pick out the fibres from some of the palms, and use them as nails; in some specimens they are as hard as rosewood. Some of the smallest palms are imported into this country for walking-sticks, under the names of partridge and Penang canes. Of the four or five hundred varieties of palm trees known to exist, only a very small number are imported into this country. The palm-woods so imported are sparingly employed for cabinet and marquetry work, for billiard cues, for snuff boxes, &c. The *twisted* palm walking sticks are the central stems or midribs of the leaves of the date palm; they are twisted when green, and stretched with heavy weights until they are thoroughly dry. The *nut*, or fruit, of many of this group of plants is applicable to uses in the Arts; such as the *betel nut* or *areca nut*, whose substance is made into necklaces, the tops of walking sticks, and other small objects; the *cocoa nut*, whose shell yields the fibre or *coir*, now used in England for a great variety of purposes, and the hard portion of the shell, which is turned into cups, vases, buttons, &c.; the *coquilla nut*, the shell of which, being hard and close-textured, is turned into knobs of umbrellas and parasols, small toys, &c. With respect to the simple wants and primitive arts of the people among whom the palms and bamboos grow, the uses of those plants are very numerous; of the *cocos nucifera*, or *cocoa-nut palm*, for example, the fruit is eaten, the husk of the nut supplies coir for cordage, the leaves are used for making baskets and mats, the lower part of the stem yields wood fitted for joists and other kinds of carpentry, and different portions of the plant are made to yield oil, sugar, palm-wine, and arrack.

But it is the exogenous or true woods which render the more important services to man, so far as regards the stem or wood itself. The fibres do not appear to differ in size or bulk so much as in density and distance; these two last-named differences give rise to the distinction between *hard* and *soft woods*—the former comprising oak, mahogany, ebony, rosewood, &c.; and the latter willow, alder, deal, &c. Another classification is that which springs from the direction of the fibres; if the annual or longitudinal fibres be tolerably straight, and very little interwoven with the medullary rays or interrupted by knots, the wood becomes *elastic* and easily rent: such are lance-wood, hickory, ash, &c.; but if the fibres are more crossed and interlaced, the wood becomes less elastic, and more rigid and tough: such are oak, beech, mahogany, &c.; and if the fibres be entangled to a still greater degree, they produce the *non-elastic*, tough, cross-grained woods, such as elm, lignum-vitæ, &c. Another mode of classification, traced with some minuteness by Mr. Holtzapffel, is

that which is determined by the beauty of the surface presented by woods. The *knots*, occasioned by the junction of a branch with the stem; the *curls*, produced by the confused filling-in of the space between the forks or springings of the branches, as in the yew; the *gnarled* appearance of the roots, formed at the points of junction of the rootlets or arms of the root with the body of the root itself, as in walnut-wood; the *pollard* growths of the oak and other trees, which owe the beauty of their grain to a crowding together of the little germs that produce the numerous shoots at the top; the *ripple-mark* surface, occasioned by a serpentine form of the grain, as in satin-wood and sycamore; the *bird's-eye* pattern, occasioned by a peculiar compression of the grain in isolated spots, as in some kinds of maple; the *silver-grain*, which results from a marked distinctness in the medullary rays, as in the plane, sycamore, and beech—all give rise to variations in the appearance of the surface of wood, which are the mainspring of the beauty observable in cabinet work. Another and very obvious mode of classifying woods is in respect to their colour.

Mr. Holtzapffel gives a tabular view of all the kinds of wood commonly used in this country. The list includes nearly eighty species of trees, without naming the varieties of each species. He classifies them according to the services which they are calculated to render. One group includes *building* woods, subdivided into those fitted for ship-building, for house-carpentry, and for hydraulic engineering; another group includes the woods most useful for *machinery* and *mill-work*, subdivided according as the wood is suitable for frame-work, for rollers, for teeth of wheels, or for foundry patterns; a third group comprises the *turnery* woods, subdivided into common soft woods, hard woods, and Tunbridge-ware woods; a fourth group is made up of *furniture* woods, separated into common and best; a fifth group comprises *ornamental* foreign woods; a sixth group consists of *dye*-woods, arranged according to colour; while a miscellaneous group is formed, subdivided according to the elasticity, the toughness, the even grain, or the durability of the wood. Of course many kinds of wood find a place in two or more of these groups; but the table is valuable, inasmuch as it brings together before the eye the names of all those woods which resemble each other in some one manufacturing quality. This table is followed by a *Catalogue raisonnée* of the woods, arranged in alphabetical order, in which the principal uses of every kind is placed opposite to its name.

But we have at the present time something better than a mere book to appeal to for instruction on these matters. The Great Exhibition, in this as in other points, is quite a storehouse of educational wealth; we cannot choose but learn, unless the visit degenerate into a mere idle lounge. The numerous collections of specimens of wood, illustrating the capabilities of different countries and districts, are in a high degree interesting. They show some among the sinews of industry, the materials of a nation's wealth; they point out whether the ship-builder or the house-builder, the coach-maker or the furniture-maker, the tasteful carver or the patient inlayer, can best be supplied with the substance on which his skill and labour are to be bestowed; and on the determination of this question depends much of the industrial organization of the district. That which a country can best produce is that which its inhabitants are most likely to bring profitably into use; and timber trees are as subject to this law as any other natural product.

Some of the collections alluded to above are confined to particular districts, each of which is illustrated by a particular collection; but others relate rather to the varied products which become grouped together in our great

emporia of commerce. Take, for example, the highly instructive specimens sent by the Dock Commissioners of Hull and of Liverpool, as part of the imports of those two great towns; from Hull we find thirty-three neatly-prepared specimens of the woods imported there, the total amount of which reaches nearly 150,000 loads annually; while from Liverpool we have about fifty specimens, similarly prepared, but more fully labelled and described. Not less interesting are the specimens sent by Messrs. Harrison of Hull. Here we find timber from every part of the world, and applicable to the wants of every kind of worker in wood. The hard, the durable, the tough, the soft, the knotted, the straight-grained, the veined, the spotted, the wood for rough service, and the wood for tasteful decoration—all are here illustrated. All our best known English timber trees; many varieties of mahogany (including the Cuban *sabicû*, of which the stairs in the Exhibition-building are formed), of satinwood, of rosewood, of tulipwood; the chief kinds of dye-woods—are here presented to view among others less known. The collection comprises nearly 200 specimens, all of which are neatly shaped, polished, and labelled; they are even fashioned like quarto and octavo volumes, each one lettered with the name of the wood which composes it. Mr. Sanders's collection is still larger, and arranged in a manner to convey more information; it comprises no less than 700 specimens; and not only are the names given, local and scientific, but also the native country, the weight per cubic foot, and the principal uses or peculiarities. To render them still more instructive, they are arranged geographically, each country by itself.

The collection sent by Mr. Cross has a more local but a more immediately valuable interest. It consists of forty-nine specimens of English forest woods, and fourteen of English orchard woods. Those visitors who have access only to the smaller catalogues of the Exhibition are deprived of much information given by the exhibitor, and printed in the larger or illustrated catalogue. The uses to which each kind of wood is applicable are tabulated in a very convenient form, in the last-mentioned catalogue. For example:—Hazel, we are told, is serviceable for small turnery, fishing rods, cotton reels, pea sticks, &c.; Elder, for shoemakers' pegs, &c.; Willow, for cricket bats, hat foundations, plait for ladies' bonnets, &c.; Dogwood, for butchers' skewers; Hornbeam, for wheel-cogs, mallets, skittles, and hard turnery; Lime, for pianoforte keys, musical instruments, curriers' cutting boards, carving, and so forth. In respect to Ash, Beech, Birch, Elm, Fir, Oak, and Yew, the list of uses is, as may be supposed, very extensive, on account of the valuable qualities possessed by those woods. Messrs. Fauntleroy's specimens of foreign hard woods are rendered intelligible in a nearly similar way. They are applicable to cabinet-work, turnery, machinery, and numerous other purposes, and comprise Box, Brazilwood, Ebony, Lignum Vitæ, Maple, Sandalwood, Zebrawood, and many other valuable kinds. It is this firm by whom has been contributed the enormous circular slab of Honduras mahogany, seven feet six inches in diameter. Messrs. Lawson's collection of the woods of Scotland shows how extensive and valuable are the timber trees possessed by our northern neighbours, and how great the service rendered thereby to shipwrights, to engineers, and others. Everything that can be done to render this collection a book which may tell its own tale, seems to have been thoughtfully attended to; not only are the botanical names and the common English names of the specimens given, but also the French and German names; the age and size of the tree whence the specimen was cut, and any peculiarities which may have distinguished it, are noted; and in order to show the wood in different states,

two pieces of most of the specimens are hinged together, the one polished and the other unpolished.

Some of our colonies have also striven to show that their store of forest wood is rich and ample, only wanting commercial energy to bring them largely into use. The "Canadian timber trophy"—a rough group surrounded by brilliant neighbours—gives us not merely daintily-cut pieces, but whole planks and logs of the timber grown in that country. It is here observable, that, although there are many varieties of beautiful marking and tints, the woods are generally more applicable to building and engineering than to ornamental purposes; in respect to woods, as to the plumage of birds and the colours of flowers, the sunny south produces more brilliancy than the cold north. Africa illustrates this principle; for among the articles sent from the Cape of Good Hope is a case containing about forty specimens of African wood, which exhibit much more depth of colour than the average of northern specimens. The British Guianian specimens are full of interest, from the variety which they exhibit and the novelty which they comprise. The greater number of these woods are almost entirely unknown in this country: the time may come, when our costly and adorned furniture (for many of the specimens are furniture woods) will derive their material from this little explored colony. The names given to the woods show how little they have yet become familiarised in England:—*kakarilla*, *wamara*, *wallaba*, *camara*, *saouri*, *yaruri*, *itikiriburaballi*, *koquerettaballi*, *towroneroo*, *warracoori*—we shall have to learn to pronounce such names. Trinidad furnishes specimens of its lignum-vitæ, ironwood, cedar, and other trees; and it is observable, that many trees come under illustration which yield well-known gums and juices—such as *gum-anime*, *copaiba*, and *fustic*. Our far-distant possessions in the East—such as India, Ceylon, Austria, and New Zealand—have all transmitted specimens of their forest and orchard woods. The Indian varieties came from various parts of the British territories; from Ceylon we have "forty specimens of ornamental and house-building timber;" from Van Diemen's Land we find *blue-gum timber*, fit for ship-building; *stringy-bark*, for house-building; *black wood*, for cabinet work; *sassafras*, for flooring, turning, and carving; and so forth; while New Zealand has sent some of its woods half round the world to the World's Exhibition. There are many reasons why the woods of India should be interesting to the artificers of the mother country, on account of the varied qualities which they present. The many hundred specimens deposited in the Indian department, comprise of course, among their number, the *teak* wood, which has become so valuable in ship-building; as well as ebony, cedar, tamarind, blackwood, wellkuan, little kuan, and almost entirely unknown woods. The labels give a great mass of information concerning the botanical and Indian names, the weight per cubic foot, the available qualities (whether "easy to work," "hard to work," &c.), and other particulars.

Many foreign countries, too, have enriched the assemblage with numerous specimens of their native grown woods. France, for example, has contributed about a hundred specimens from Algeria, of various forms and sizes, but mostly polished. Spain—little able as she is, in her present depressed commercial state, to take part in these industrial displays—has forwarded a valuable collection of woods from her important colony of Cuba; they are neatly prepared, and labelled with the ordinary names, and were sent to this country from the Botanical Garden at Madrid. Spain has also contributed 213 specimens from the Philippine Islands, each specimen cut into a cube

about two inches square. Northern Italy has forwarded to us about thirty polished panels, which illustrate the kinds of ornamental wood found in that region. From Portugal there is a small and humble group of specimens. The Austrian Government has forwarded, from M. Bienert, of Maderhäuser, in Bohemia, a collection of plain woods, light in colour, remarkably neat and clean in their general appearance, and apparently well fitted for cheap furniture and for carving. Even Turkey has contributed a few rough-looking specimens, labelled with inscriptions in the Turkish language. Professor Noerdlinger, of Hohenheim, has adopted a very interesting mode of exhibiting the qualities and internal structure of various kinds of wood; his collection consists of a considerable number of small pieces, cut so as to show the grain and the bark; and besides this there is a book, between the leaves of which are exceedingly fine films cut from the various specimens, so as to exhibit the ligneous structure in all its delicate beauty. Lastly, we may notice that among the rough but valuable contributions of raw produce from the United States are two or three hundred specimens of woods, mostly in quadrangular pieces about a foot in length.

## The Maladies of Timber, and the Remedies.

The present century has been marked (as is fitting that it should be) by very active inquiry into the nature of wood, the structure of its fibres and cells, the derangements to which the fibres are subject, the effect of these derangements on carpentry and ship-building, and the best mode of removing the evil. The chemists and the physiologists have been asked to lend their aid in the solution of various problems connected with these subjects; the aid has been afforded; and the result adds to the number of those which show how boundless are the relations of amity and mutual assistance between science and industrial art.

There have been many curious facts ascertained concerning the qualities of different kinds of timber, as affected by position, soil, moisture, and other circumstances. Wood taken from near the heart of a trunk or near the bark is weaker than that from an intermediate position, and the parts near the root are stronger than the parts near the junction of the branches. A tree grown in dry soil, other things being equal, produces timber which is harder, heavier, finer grained, stronger, and of a deeper yellow colour, than if grown in a damp soil. Some woods lose but little weight in seasoning; some will become of greater specific gravity than before, as they gain more by condensation of fibre than they lose by evaporation of moisture; but in most cases the wood becomes lighter than before. In shrinkage by drying the diminution almost always occurs in the breadth, and not in the length.

But it is in relation to the causes of *decay* in wood that investigations have chiefly been made. How remarkable are the evidences often furnished of this decay! There is in the Great Exhibition a piece of a pile-timber which had been for some few years beneath the water at Lowestoft; it is honey-combed in every direction, and reduced to such a state of disintegration that it may be crumbled by the fingers. Examples of this kind must be more or less familiar to most persons. The process of reasoning, by which the cause of this decay is pointed out, is somewhat as follows—divested of scientific strictness and brought into familiar language. All trees contain within their pores a kind of albumen, which contributes to the sustenance of the plant; but when the tree is felled, and the trunk and branches converted into timber, this albumen

becomes an evil instead of a good—a source of mischief which would willingly be dispensed with. When the albumen is moist (which it always is before the timber is seasoned), it has a tendency to enter into a sort of fermentation; if this state commences, the albumen becomes a favourite relish for certain minute animals, who forthwith bore for themselves invisible passages through the wood, to attain the object of their search; these passages admit air and moisture, which so act upon the chemical constituents of the sap as to afford a kind of soil in which minute parasitical plants grow; these plants, sprouting out, force holes for themselves through the wood, and appear on the surface as *dry-rot;* and the holes by degrees become so large as to render the timber a mere skeleton—a dry sponge of fragile fibres. This is, we believe, the modern explanation of dry rot, or something near it.

Timber growers and timber dealers, timber sawyers and timber users, are not likely to sit down quietly and let decay do its work unmolested. They may not have known in past times all that is now known concerning the cause of decay, but they had certain theories which led them to try experiments. Indefatigable, indeed, have been the attempts to find out some chemical mode of protecting timber from ruinous decay. As fast as one method was tried and found to fail, another started up, and to this untiring energy we owe the excellent methods now in practice. It is (as in so many other instances) the first half of the present century that has chiefly borne witness to them; but the last century effected something in the matter. Dr. Hales recommended sulphate of copper as a steep-preservative for wood. Dr. Fordyce substituted sulphate of iron, which rendered good service in the wood of some timber houses in Jamaica. Colonel Congreve, in 1784, proposed the adoption of oil of tar as a coating for wood. Towards the close of the century Sir Samuel Bentham patented a mode of extracting the air from the pores of wood, and forcing chemical agents into the pores thus vacated: this was a germ from which many subsequent methods have been derived, but it failed of realisation under the inventor's hands. Then came a multitude of proposals respecting the substance to be employed—coarse whale oil, oil of birch-bark, unslaked lime, pyroligneous acid, &c. Some buried their timber for a while in hot sand; some put it in chambers filled with heated air; some exposed it to steam; some coated the surface: indeed the plans proposed during the early part of the present century were so numerous that we may consider the present adopted methods to be improvements rather than novelties.

How to get rid of the albumen, or how to modify it—this is the inquiry. It cannot be driven out; and if dried, it has a tendency again to absorb moisture. Hence chemists have recommended, and practical men have adopted, modes of rendering the albumen *insoluble,* by combining it chemically with some other substance: being made insoluble it defies moisture. Then arose the question —What chemical agent shall be employed? Sir Humphry Davy suggested corrosive sublimate; Mr. Kyan has adopted this plan under some modification; Mr. Bethell prefers creosote oil; Mr. Payne employs sulphate of iron and barytes; while Sir William Burnett selects chloride of zinc. But supposing the chemical theory be sound, there are yet other difficulties to surmount; these solutions cannot reach the pores of the wood until the air has been expelled, and for a long time this difficulty baffled the experimenters. The plan now adopted is highly ingenious. The timber is placed in a very strong cylinder, provided with a suction air-pump and a pressure liquid-pump: the air is pumped out of the pores, and the liquid solution (whatever it may be) is then pumped in.

The Industrial Exhibition has its full share of specimens illustrative of

these valuable and ingenious operations. Sir William Burnett, for instance, exhibits specimens of "Burnettized and un-Burnettized timber," as proofs of the different way in which damp affects wood, according as it has or has not been steeped in the chloride solution. There are also pieces of canvas, cotton, woollen, and raw hides, tested to demonstrate the efficacy of the process. In order to complete the series, there are bottles containing the preservative liquid, and drawings of the machine employed to inject the liquid into the pores of the wood. Mr. Bethell's system is illustrated in an analogous way. He exhibits specimens of wood saturated with oil of tar by a process which he designates "creosoting;" pieces of creosoted sleepers, which have been used for some years on railways without undergoing any decay; pieces of wood in an unprepared state, showing the ravages of the *Teredo navalis* and other insects; and other proofs of contrast between decay and soundness, tending to illustrate the subject under consideration. In the Mecklenberg section of the Exhibition there is an interesting group of specimens put together in the form of a ship; the pieces have been impregnated with pyroligneous acid, and the object is to show that inferior kinds of wood, if treated in this way, may render good service in ship-building.

There is a slightly different philosophy involved in Messrs. Davison and Symington's *desiccating* process for timber. Here the pores of the wood are thoroughly dried by means of hot air, aided by a rapid current. If a beam of timber were shut up in a vessel of stationary hot air, it would be *baked;* if there were a little current, but not sufficient, the wood would be *stewed;* and this baking and stewing have accompanied many modes of drying timber by heated air. The new method obviates the evil, by carrying off all the moisture from the wood through the agency of a rapid current. Mr. Newton has sent to the Exhibition specimens of wood which have been exposed to the desiccating process. Each specimen is inscribed with various particulars concerning its dimensions, the time during which it has been exposed to the desiccating process, &c. Even timber which is considered to be well seasoned by the ordinary method loses ten per cent. of its weight on further desiccation, thus showing how much moisture has still been left in the wood. An important consequence results from this more perfect drying; the wood being rendered more homogeneous, vibrates more equally under the influence of sound, and forms more efficient sounding-boards for musical instruments. Mr. Willis's great organ is made from wood thus seasoned. Another unexpected benefit is, that new beauties are developed in the grain of the wood: many cheap kinds of wood being found to present a colour and surface more attractive than when imperfectly dried by the usual means.

It was an extraordinary conception of a French physician, Dr. Bouterie, to send these anti-dry-rot agents into the pores of *the living tree itself*. He has a method of causing the tree to imbibe certain liquids in the same way as it would ordinary moisture. The liquid kills the tree, but the timber is rendered antiseptic. There is no knowing yet how much this method may be capable of effecting; for the inventor claims the power of imparting any *colour* or any *odour* he pleases to wood by analogous means.

The carbonization of wood by high-pressure steam is one of the apparent paradoxes of recent times. How can steam—a moistening, wetting vapour—impart a scorched or carbonized quality to wood? It seems contrary to all our usual experience. The truth is, that in our every-day processes steam has a temperature very little, if anything, above that of boiling water (212° Fahr.); and at that temperature wood would be soaked but not scorched; whereas

high-pressure steam is heated to a far greater degree, and the damp quality (if it may be so termed) is overpowered by the hot quality. M. Violette communicated a paper to the Académie des Sciences, in 1848, in which he pointed out the curious results of this highly-heated steam upon wood, and showed that these results enable us to prepare charcoal of any desired quality. If wood is exposed to temperatures varying from 400° to 700° Fahr., it becomes charred, or converted into charcoal, varying from light brown to deep black; and these different qualities of charcoal are applicable to different useful purposes, in making gunpowder and other substances. Now it is found that steam-heating enables the charcoal burner to produce and maintain a definite temperature, and thereby to manufacture a definite kind of charcoal at pleasure. M. Violette raises the steam to the desired degree in a boiler, passes it through a tube to a cylinder containing pieces of wood, allows it to act by its heat on the wood, and to carry away the distilled products of the wood when it escapes from the cylinder. The charcoal becomes thus not merely browned or blacked to a pre-arranged degree, but it is rendered more like pure carbon by the abstraction of various volatile ingredients. There is something highly scientific in this conception.

Besides the collections of woods noticed in former paragraphs, many specimens are to be found in the Exhibition illustrative of some process or other to which the wood has been subjected. Mr. Stow, for example, has specimens of wood which have been stained without the aid of heat or moisture,—a process said to be applicable equally to plain and to carved wood. An exhibitor from Swansea shows us a piece of Welsh oak, prepared by a peculiar process as a substitute for fancy wood. Another group of specimens comprises cheap woods which have been stained with certain liquid solutions, and then varnished; the exterior woodwork of the Crystal Palace has been thus treated, and illustrates the mode in which deal may be decked out more cheaply and expeditiously than by painting and graining. The imitations of marble in wood, and of costly woods in others of humbler kind, are numerous in the Exhibition, but too familiar to need notice, except that some of them display remarkable beauty.

Wood, like many other substances, is now brought within the scope of pressing power. The rolling mill, so extensively adopted for metals of almost every kind, is also applied to wood; but not for the same purpose; for while metals are sought to be made *thinner* by the process, wood is made *harder*. A patent was obtained a year or two ago with this object in view, wood being much stronger when compressed or condensed by pressure. In one machine pieces of wood for making wedges are compressed so forcibly between two dies as to have a definite angle given to them, and great hardness to the substance of the wood; in another machine small pieces of wood are compressed into the proper forms for railway pins and ship's treenails; in a third machine planks are pressed throughout their whole length by passing between rollers. Let it but once be determined that wood so treated becomes strengthened, and we shall witness abundant variety in the application of the principle.

## Steam-Power Carpentry.

As the present century has witnessed many additions to the number of woods applied to useful and ornamental purposes, and many excellent modes of preserving timber from decay, so has it been equally prolific in new modes of fashioning timber for practical uses.

The "top sawyer" at present is certainly the steam-engine, and such seems likely to continue to be the case. Year after year steam power becomes more and more employed in cutting bulky timber into planks and staves. It is said that there are no fewer than seventy steam saw-mills in and near the metropolis. These supersede to an unequal degree the labours of hand sawyers; the latter are grouped in four classes—timber sawyers, hard-wood sawyers, coopers' sawyers, and ship sawyers; and the steam-engine is applicable to some of these kinds of labour more than to others. The hard-wood sawyer has to exhibit much tact and skill, since the valuable furniture and cabinet woods on which he is employed have to be economized as much as possible. The coopers' sawyers cut the staves for casks, a kind of work which is now sometimes accomplished by cask-making machines. The ship sawyer cuts the curiously twisted timbers for a ship, the curved surfaces of which require much care on the part of the sawyer. But the common timber sawyer, who prepares the deals and other common woods for carpentry and similar purposes, is the one whose labours are most likely to be superseded by dumb agency; the work is coarse, hard, monotonous, and requires very little thought.

From the earliest times of which we know anything definite, the sawing of timber has been performed pretty much in the same way: the paintings and bas-reliefs in Egypt tell us thus much. The top man and the pit-man, the pit and the scaffold, are what they have been for centuries, with very little modification. Every one must see that the labour at a saw-pit is of a very severe kind. In one of the remarkable papers published in the *Morning Chronicle*, some months ago, on the Labourers of London, a sawyer's estimate of his daily physical exertion is given. In the first place, he says that his saw weighs from 60 to 70 lbs., that it is about 7 ft. in length of blade, and that he and his partner make about 10 strokes a minute; this is equal to 70 feet per minute, or 4200 feet per hour, or 42,000 feet in a day of 10 hours—in other words, two men lift 60 to 70 lbs. nearly 8 miles high in the course of a day's work. But this is only half the labour, perhaps less than half; in the up stroke the men have only to lift the saw, but in the down stroke the teeth catch like so many sharp hooks in the substance of the wood, and tear it away by main force. The sawyer was too unlearned to estimate the amount of this force, but he had heard "a scientific man calculate and reckon" that it was equal to lifting 86 lbs. If this be correct, it more than doubles the former figures, and presents a formidable appearance. Even supposing the sawyer and his scientific informant to have been not strictly accurate, there is abundant room for thinking that the labour must be severe, and that it is a kind peculiarly fitted to be brought within the scope of steam power.

For a few years before and after the commencement of the present century, horse power was occasionally used to facilitate the labour of sawing: but it was about forty years ago that the first steam saw-mill was established near London. The horse-mills were abandoned, partly through the opposition of the sawyers, but more effectively through the system being non-remunerating. The steam mills have proved to be efficient and advantageous, and have been increasing in number year by year. In most steam saw-mills there are three frames of about nine saws each: this may be taken as an average. The straight saws, which have a reciprocal or up and down motion, make 150 to 180 cuts in a minute; while the circular saws, usually from 18 to 36 inches in diameter, have a revolution of 1500 to 2000 times in a minute—a speed which enables them to cut through wood with great ease and rapidity. The teeth

are much finer than in the saws used by pit-sawyers, and therefore cut cleaner; being subject to more regular and precise action, they need not be made of such highly-wrought steel as pit-saws, and are on that account cheaper; and in cutting a given quantity of timber, a machine saw requires sharpening less frequently than a pit-saw—three points of advantage which the new fashion has over the old. Among the curious calculations connected with this subject, one is, that every tooth of an 18-inch circular saw, working at average speed for ten hours a day, travels 900 miles in that time.

But *veneers* are the forms into which a steam-mill best shows its power of sawing timber. It is in fact now entirely a machine process in this country. The late Sir M. I. Brunel—that extraordinary man, whose inventive mind produced such fruitful results in a professional career of half a century—was the parent of the saw-mill. He invented it about forty years ago, patented the invention, and leased the use of the patent to many different persons. This was for timber-sawing only; but his ever-active mind did not fail to see the applicability of the method to veneer-sawing. He spent two years in the endeavour to surmount unexpected difficulties which presented themselves; he did surmount them, and veneer saws have ever since remained nearly as he left them. He, with one or more parties, established a veneer sawing-mill at Battersea; the mill is still at work, but has passed into other hands.

It is really a beautiful example of mechanical action which is presented by this veneer sawing. So unerringly are the thin plates cut, let the grain of the wood be hard or soft, straight or twisted, that the use of veneers is becoming more and more extensive every year. Not merely mahogany and rosewood, for ordinary drawing-room furniture, but satin-wood, Amboyna-wood, zebra-wood, tulip-wood, ebony, Coromandel-wood, maple, cedar, sandal-wood, king-wood, and other foreign woods, are similarly cut. Nay, our own English oak, yew, elm, ash, birch, walnut, sycamore, &c., are wrought into thin films by similar means. The logs of wood, when about to undergo the sawing process, are first brought to a tolerably clean surface by the adze or the plane, and are then firmly fitted into a frame. The veneer-cutting saws are of enormous size, some of them reaching to seventeen feet in diameter; they are circular, and are built up of several pieces of steel, for it is found that a single plate has a tendency to become distorted by the heat generated during sawing. The adjustment of the saws is most extraordinary for its exactness. Let us consider that as many as fifteen veneers are occasionally cut in an inch, and that any deviation from parallelism would render them ragged and useless; we can then conceive what nicety of arrangement is required. The saws rotate with great velocity; the log moves on by automatic machinery to meet the saw-cuts; the saw-dust falls to the ground in fine powder; and the aroma from the wood (for each kind of wood has its own peculiar aroma when heated by the friction of the saw) fills the apartment. Thus is veneer-cutting now conducted; and when we are told that the machine can cut nearly twice as many veneers in an inch as the most skilful sawyer, we see ample reason for the change in the working economy of this trade. The English usually adopt the method here described; but on the Continent a singular mode is practised of cutting a continuous veneer in a spiral form; the English plan wastes a little more wood, but yields stronger veneers than the foreign. There is a film of ivory veneer in the United States department of the Exhibition, forty feet long by a foot in width; produced by cutting the tusk spirally or in snail-like fashion.

Like most other steam-power operations, timber-sawing now undertakes more than it was once thought capable of effecting. The elder Brunel thought he

had wrought a great work (and it *was* a great work) when he showed how to saw a huge log into planks by steam power; but modern inventors are not satisfied with this; they wish to make *crooked* saw-cuts as well as straight, for the production of ships' timbers; and they have attained their object. About three years ago, there was a legal contest between two inventors, an Englishman and an American, as to their respective rights to new timber-sawing mechanism; into the merits of the litigated question we do not enter; but it is interesting to note that both inventors had produced machines for making either straight or crooked saw-cuts in timber. Mr. Cochran's machine (one of those here alluded to) is a very complicated piece of apparatus; the fixing of a log of timber, the slow movement of the log as the cutting proceeds, and the reciprocating movement of the saws, are all effectively managed. But when the log is to be cut in a tortuous form, for ship-building and other purposes, there is provision for giving a rotatory or partially rotatory motion to the log; and, what is still more remarkable, the saw is made to shift or oscillate so as to cut successively in many different directions: nay, there may even be two saws working at once, the one cutting straight and the other curvilinear. This machine has been worked at Woolwich Dockyard; and we believe it is now undergoing that ordeal of lengthened trial which must necessarily precede any general adoption of such contrivances. It is said, that at the Earl of Rosse's first *soirée*, as President of the Royal Society, a model of this timber-cutting machine was exhibited; and that the Prince Consort cut a miniature ship's timbers with it to test its action:—a pleasant apprenticeship this, for one who was destined to be the founder of the greatest industrial jubilee the world has ever witnessed.

Not only is the giant power of steam now applied to the fashioning of wood for the purposes of the carpenter and the joiner, but there are establishments expressly appropriated to this purpose. These are much more modern than steam saw-mills, and contain machinery of a more complicated kind; most of them, however, comprise machine-worked saws as well as planing and moulding machines. Until about twelve or fourteen years ago, the few planing machines in use were wrought by hand, but the all-embracing steam engine is now applied with much better effect. The same movement sets to work the saws for cutting boards to the proper width, adzes for bringing the board to regular thickness, and planes for smoothing the surface; and it is said (and may readily be believed) that the boards so prepared are flatter and smoother than those planed by hand. In the *moulding-mills*, as they are called, the operations are of greater nicety, for the wood has to be fashioned to those architectural forms which constitute mouldings, such as are used by carpenters, joiners, and others. The cutting tools are small pieces of steel, fashioned to the shape of the moulding, and fixed to a rapidly-revolving axis; the wood is brought to the action of these cutters, and a perfect shower of little fragments of wood is all that tells us what is going on, for the revolution is too rapid to allow the movement and action of the cutters to be traced.

The great lesson-book in Hyde Park affords its teachings on this subject as on others. There are five different kinds of wood-working machines exhibited by Mr. Furness. One is a *morticing* machine, intended to cut holes for the tenon-and-mortice mode of joining timbers. There is a second morticing machine, moved by the foot instead of by steam power, and fitted to cut holes from an eighth of an inch to two inches in width. A third is a *tenoning* machine, for cutting those projections which constitute tenons; each tenon is com-

pletely shaped at one operation. A fourth is a *planing* machine, for giving a flat and smooth surface to planks or any other pieces of wood; the powers of this machine are so easily adjustable as to be easily applied to timbers of all dimensions—from four to fifty feet in length, from eight to forty inches in width, and from a quarter of an inch to thirty inches in thickness. A fifth is a *moulding* machine, to impart to wood the architectural form of mouldings, which are usually wrought by the carpenter with the aid of hand-planes; it may be applied to the making of sash-bars, or the cutting of grooves, or the forming of any hollows or protuberances which are to extend uniformly along the grain of the wood; and it is applicable either to hard or soft woods, with a slight adjustment.

Besides various English machines of this kind, there is a French machine, called the 'Menuiserie Mécanique,' or Mechanical Joiner, which both planes and forms mouldings in wood, by plane-irons fixed to an axis which revolves a thousand times in a minute.

## Wood-Work of the Crystal Palace.

So intimately did the achievement of Messrs. Fox and Henderson's vast enterprise depend upon the employment of machine-carpentry, that we cannot select a better place than the present to notice a few of the "Curiosities" connected with the wood-work of the Crystal Palace. In a structure which contains 600,000 cubic feet of wood, and in which the ground floor and the galleries contain 1,000,000 square feet of flooring boards, the execution of the carpentry must needs have been an important matter.

The sash-bars of this notable structure are to be measured—not simply by dozens or scores of miles—but by hundreds; for the total length is rather more than 200 miles! This may seem almost inconceivable at first; but if we glance upwards when walking along the central nave, or view the four façades in the exterior, we shall begin to realize the startling fact. Great indeed was the need, when these hundreds of miles of wood-work were to be shaped in such a short space of time, that the mighty aid of the steam-engine should be sought. Mr. Paxton on his part, and Messrs. Fox and Henderson on theirs, brought the resources of mechanism to bear on the subject; and the sash-bar contrivances were not among the least curious of the many Curiosities of Industry displayed in this memorable building.

Each sash-bar was originally a four-square piece, measuring an inch by an inch and a half in width and depth; but, during its passage through the machine, all the four edges were bevelled off, and grooves cut in two opposite sides. A plank entered at one end of the machine: a number of finished sash-bars came out at the other. In the first place, the plank encountered numerous cutters, above and below, which made as many pairs of grooves as there were bars to be produced from one plank; while other cutters made the angular incisions which were to constitute the bevelling. The plank next came in contact with a set of parallel circular saws, by which it was speedily ripped up into separate bars. About three hundred planks were thus cut into sash-bars by one machine in a day. The bars were then cut to lengths of forty-nine inches, and transmitted to Hyde Park, where other ingenious machines fitted them for the exact places they were to occupy. They were cut most accurately to a uniform length; a notch-piece was cut out near one end, to form a shoulder for resting against the gutter; the ends were bevelled off to the required angle; and nail-holes were drilled in the proper places for fastening the bars to the gutter and ridge.

The various angles at which the component pieces of wood-work in the roof meet each other required the greatest nicety of adjustment; and we accordingly find that—whether we look at the sash-bars, the ridges, or the gutters—there were many curious contrivances adopted. The ridges stretch in long unbroken lines from east to west, and are obviously much less in quantity than the sash-bars; they extend, in fact, about sixteen miles. But they are much thicker and stronger than the bars. They were formed out of pieces of timber three inches square, which were passed through an ingenious machine capable of cutting grooves for the reception of the upper end of the respective panes of glass; and the top of the piece of wood was, by the same machine, moulded into an ornamental form.

But the "Paxton gutters" required more machine-work for their construction than even the sash-bars or the ridges. These gutters extend east and west, midway between the ridges; they serve to support the lower end of the sash-bars and of the panes of glass, and at the same time to afford clear channels for rain-water on the exterior of the building, and for condensed moisture on the interior. The shape thus required to be given to them is a very singular one; and nothing less than the exercise of great ingenuity could have enabled the contractors to produce twenty miles of such gutters as fast as they were wanted. Each of these gutters has a hollow trough on the top for rain-water, a small channel or groove on each side for condensed moisture, and bevelled ledges at the top to serve as resting-places for the glass; all these nicely-adjusted hollowings and bevellings were effected by machinery; and the gutter had also to possess the requisite qualities, as a rafter, to span the space of twenty-four feet from one roof-girder to another. The mechanism for producing these results was varied and powerful. In the first place the baulks of timber, roughly sawed by the usual process, were planed on all their four surfaces by Mr. Furness's Planing Machine (lately noticed) at the Chelsea Saw Mills. Each timber was then passed to the gutter-cutting machine, the machinery of which was very curious. A number of cutters, variously shaped, were placed one behind another; and as the timber was urged on towards them, it was subjected to the action of each one in succession; one cutter made a first incision for the rain trough, another deepened and curved it, others made the bevelled top edges, and others the lateral condensed-water channels; so that by the time the timber had passed through the machine it assumed the form of a Paxton gutter. (This term is a familiar one, and we use it; though it is not the best that might be chosen.) The machine continued its work until it had produced a length of gutter which would extend pretty nearly from the Crystal Palace to Windsor Castle.

The transverse gutters form another part of the roof timbers; but, as their construction involved only common carpentry operations, we need not stop to describe them.

Mr. Paxton stated to the Society of Arts, in a paper read before that body, that he had tried many methods in order to determine the most suitable *floors* for the pathways of horticultural structures. He found stone, close boarding, and other methods, objectionable, and ultimately determined in favour of open boarding, with spaces between the boards through which dust may disappear. The flooring boards of the Hyde Park structure are one inch and a half thick, laid half-an-inch apart, upon joists nine inches and a half by seven inches, which rest upon large timbers or sleepers thirteen by three and a quarter inches, at intervals of eight feet apart. The half-inch apertures between the boards afford an escape for the dust from five or six million pairs of feet.

The "Great dust question" he treated as follows:—"Before sweeping the floors of the great building, the whole will be sprinkled with water from a moveable hand engine, which will be immediately followed by a sweeping machine, consisting of many brooms fixed to an apparatus on light wheels, and drawn by a shaft. Through the interstices left between the boards the dust passes." The reader will perhaps remember that the designer has since jocosely thanked the lady visitors on the "five-shilling days" for having swept his floor so clean with their trailing dresses.

The bewildering acreage of flooring required machine-aid as well as the sashes and the girders. A very ingenious adzing and planing machine was employed. It planes one side, while at the same time it adzes or removes irregularities from the other side. To effect this, the plank is made to move slowly over a table; and while so moving, two adze-cutters work upon the upper surface, and three plane-irons upon the lower; and to complete the automatic action of the machine, two circular saws rip the plank to the exact width required, before it leaves the table. The flooring of the galleries is much more nicely constructed than that of the ground story, since it is necessary to prevent dust from falling between the boards upon the costly treasures beneath. To ensure this, not only are the boards fitted close together, but both edges of each board are grooved, and iron tongues or plates are inserted in the grooves.

Even the handrailing for the galleries called for the exercise of a very ingenious machine, which was worked within the building itself. This railing is made of mahogany, and is of cylindrical form. The mahogany was brought to the building in broad thick slabs or planks; it was first cut into quadrangular lengths by circular saws, and the saws next gave an octagonal form by bevelling off the four corners. Each piece, twenty-four feet long, was then passed through a hollow cylinder, near the entrance of which were four cutters revolving with great rapidity; and the mahogany was by these cutters brought to a cylindrical shape and a very smooth surface.

The beautiful transept-arch has very little iron in it. Wood forms nearly the whole material of the opaque skeleton of this noble work. The main support is afforded by sixteen semicircular timber ribs, placed twenty-four feet apart, and having a span of no less than seventy-two feet. Between every two adjacent ribs are minor ribs of timber, eight feet apart, not intended to render any considerable support to the structure, but to give holding-ground to the ridges, the Paxton gutters, and the sash-bars. The making of these wide-stretching timber ribs involved nothing more than mere carpenter's work: it was in the general conception, and in the raising of them to their places, that the inventive talent of the constructors was displayed. If we were to take a section of one of the ribs, we should find that it consists of six pieces of wood and two of iron, presenting an area of eighteen inches by eight. The minor ribs for the ridges and furrows are also formed of several pieces each, bent round to the curve and bolted together; but much less ponderous than the main ribs. The hoisting of these ribs was one of the most difficult tasks among the many which the contractors had to meet. They were made, or built together, on the ground, and had to be raised to a height exceeding a hundred feet. As the span is very great in proportion to the thickness, two ribs were fastened together at their proper distance apart to stiffen or strengthen them; and the mass of framing which had thus to be lifted measures seventy-two feet in one direction, sixteen in another, and thirty-six high. Each rib was raised exactly in the centre of the transept, and then moved on

rollers northward or southward to its destined place—the central rib being the last one raised. It was the labour of one hour to raise the first rib; and this hour (on the 4th of December) was one of great anxiety and interest to commissioners, designer, contractors, foremen, and workmen; for the enterprise was one of equal novelty and daring. The success was complete; and the 12th of the month witnessed the raising of the last rib.

## Wood in its Every-Day Applications.

In the first paper of this series, a little was said concerning the excellent effect produced on the glass manufacture by the removal of the Excise duty. A less, but still important improvement will result from the recent change in the timber duties. If Canada asks to be sheltered under the wing of the mother country, by favoritism in respect to these duties, it is for the statesman to decide on an answer to this demand; the worker in wood ignores the claim, and will have nought to say to it. He wants the wood of Britain, of the Baltic, of British America, and of other countries; he is willing to pay the proper commercial price for them, and will then apply each kind to the purpose for which it seems best suited. Nothing less than freedom of this kind will fully determine the relative qualities of wood.

Ship-building seems likely to be influenced by this sort of freedom in the selection of timber. Not only are Indian teak and African ironwood now attracting attention, but an interesting volume has lately been published, pointing out the advantages attending the use of mahogany in ship-building. Even the repeal of the Navigation Laws may tend in the same direction; for our shipowners, under the influence of foreign rivalry, will eagerly avail themselves of any researches into the qualities of timber, calculated to render their vessels stronger or cheaper. In the construction of viaducts for railways, timber has rendered most valuable service; but as a material for paving in streets, it has been "tried and found wanting."

In our private dwellings, and in household furniture, novelties have been introduced in respect both to the material and the processes. The variety of woods employed for our tables and chairs, our sideboards and pianos, is greater than it was twenty or thirty years ago. Especially is this observable in respect to fancy woods, veneered on others of less value. The carpenter is still the artificer who fashions the rough woodwork for a house, and the coarse articles of furniture: the cabinet maker (the "tischler" of the Germans and the "ébenist" of the French) is still the fabricator of the more costly articles of furniture: but both are now aided by machinery where handwork used to suffice. The baulks of timber are ripped into planks by steam-saws for the one, and the logs of mahogany and rosewood are cut into veneers by steam-saws for the other. Sooner or later this system will assuredly spread. Mr. Cubitt's fine establishment at Pimlico illustrates the mode in which the factory system is becoming applicable to building operations. It is, in fact, a house-factory, on a grand scale. There are joiners, carpenters, bricklayers, masons, painters, plasterers, smiths, engineers, moulders, brickmakers, sculptors, architectural draughtsmen—all are employed by the establishment, manufacturing houses by wholesale. Confining our attention to the subject of this paper, we may mention, that in accordance with the vast scale on which operations are conducted by this firm—whole streets of doors, of sashes, &c., are made consecutively, and laid aside in the drying rooms till wanted. Every kind of work at which steam-machinery can usefully be em-

ployed, is wrought by that means; the timbers are sawed, the boards are planed, the sashes are grooved, the mouldings are shaped—all by steam power.

The Great Exhibition has given us much valuable information concerning the employment of wood in furniture in foreign countries. Some of the woods are very different from those employed in England; some are wrought in a more heavy and massive style than would be admired here; while others are lightsome to a degree which we are not accustomed to. It may with safety be asserted, that only a relatively small number of English persons were prepared to expect from Vienna such furniture as the firm of Carl Leistler has contributed to our Exhibition. Austria—partly from her insufficiency of sea coast and of commercial harbours, and partly from political causes—has but a small amount of trading intercourse with this country; and it is the select few only, of our countrymen, who have visited the Viennese at their own homes. The suite of rooms has therefore come upon us as a surprise; and it is certainly one worthy of study. The *dining-room*, with its dining-table for forty persons, its sideboard, its set of chairs, and its inlaid flooring; the *library*, with its two magnificent bookcases, its table, chairs, and inlaid flooring; the *drawing-room*, with its loo-tables and work-tables, its corner and side tables, its revolving picture stand, its chairs, and its inlaid flooring; the *bed-room*, with its sumptuous but heavy bedstead, its chairs, stools, "prie-Dieu," sofa, tables, Italian cupboards, and inlaid flooring; the *ante-room*, with its oval table, loo-table, &c.—all serve to illustrate the beauty of the wood employed, the excellence of the workmanship, and the difference between English and Austrian furniture in general arrangement. The parquetry flooring is a hard and polished substitute for the carpets of English houses. This kind of manufacture, we are told, "has lately increased in an extraordinary degree. Vienna, Prague, Budweis, Plass, Dobrzisch, and also Dermes in Hungary, supply works of this kind in large quantities, and of increasing perfection." The floorings are sold complete, or in squares of considerable dimensions. The catalogue-prices represent them at 50 to 160 florins per 100 square feet (10*d.* to 2*s.* 9*d.* per square foot).

While looking at these highly-finished specimens of Vienna workmanship, it is interesting to see what the Official Austrian Catalogue says of the cabinet making of that country. "Architectural carpentry [this designation has rather more meaning in it than our term cabinet-work] is carried on in the towns on a very considerable scale. Although several large establishments of this kind exist in the more populous parts of the empire, their productions are not calculated to meet more than the local demand for them. Within these very few years, a factory has been established at Vienna, to produce doors, lintels, and window frames, &c., both by machinery and by hand; and being in connection with a factory of inlaid floorings and a furniture warehouse, forms a portion of the splendid establishment of Messrs. Carl Leistler and Son, which for taste and workmanship stands without a rival."

Of the white wood carved furniture of Switzerland; of the Jersey sideboard, with its bold carvings of King John and his barons; of the Kenilworth buffet, with its elaborate Shaksperean scenes; of the exquisitely carved cabinets and tables from Florence; of the cabinet and inlaid furniture from various foreign countries;—we have no space here to treat. There are other matters which rather claim attention in this place.

A word or two respecting *Turning*. This art, like most other mechanical occupations, becomes divided and subdivided as the wants of society increase,

and the principle of the division of employments becomes recognised. Thus, the *general* turner produces the pillars, posts, legs, knobs, and other articles required by cabinet-makers and upholsterers; the *hard-wood* turner exercises his ingenuity in preparing chess-men, billiard balls, twine boxes, skittle balls, toys, &c., in ivory, ebony, box, lignum-vitæ, and other hard woods; the *tassel and fringe* turner works only upon soft wood, such as lime, alder, and chestnut, with which he manufactures the small turned centres or cores of tassels and similar articles; the *bobbin* turner produces the millions of small bobbins and reels on which yarns and threads are sold; the *plumber's* turner is a worker in hard woods; he employs beech, elm, ash, box, and other hard woods, in making suckers and buckets for pumps, lead-dressers, mallets, wedges, and a number of implements used in various mechanical trades; the *brush* turner makes the soft-wood broom heads, brush handles, &c. There are other minor divisions, employed upon special branches of wood-working.

Here, as elsewhere, the steam-engine is gradually putting in its claim to become a universal artificer, a substitute for bone and muscle. The piece of wood which is being turned must have a rotatory motion given to it, and this is the duty which steam-power is most fitted to fulfil. Under all ordinary circumstances the turner maintains the requisite rotation by pressing his foot on a lever or treadle: this is the unskilled labour, the mere exercise of muscular force, which comes legitimately within the range of steam-power. To guide the tool itself is a very different affair; here an accurate eye, a delicate touch, and something approaching to taste, are needed. Yet even here the genius of steam claims entry; steam-power, as we have said, wholly turned the mahogany hand-railing which runs round the galleries of the Crystal Palace; and there are indications that, wherever large quantities of one pattern are required, the same most pliant but most irresistible power will become more and more an adjunct to the labours of the turner.

Turning has its "curiosities" like every other trade. It is said that the common painted sham bamboo bed-room chairs are turned very largely in Buckinghamshire. This is by no means a manufacturing county; and it may seem odd that such a branch of industry should be so located; but when we find that those chairs are made chiefly of beech, and that Buckinghamshire is somewhat famous as a beech-growing county, a little light is thrown in, which may help us to solve the puzzle. Another of the curiosities of this trade is worth noting. In turning large articles, the foot of the turner has not power sufficient to keep the lathe in motion; he employs a "wheel-turner" to do this for him; and it is found that *blind* men are preferred for this service to others, as the concentration of their attention to one object enables them to turn the wheel with more regularity than those who, having the privilege of sight, are apt to use that privilege in gazing about them.

The process of turning involves a number of "prettinesses" which render it rather a favourite among amateur workmen. Lords and right honourables, clergymen and students, are ranked among those who have played at work in this direction; and the late Mr. Holtzapffel's elaborately-illustrated treatise was written quite as much for amateurs as for shop-workmen. Nay, it appears that regal dignity itself has found enjoyment in front of the lathe. Louis XVI., we believe, played at locksmithery rather than turning; but one of our own monarchs seems to have been learned in wheels and treadles, chucks and chisels. Mr. Henry Mayhew states that an old working turner, gossiping over the reminiscences of his trade, said, "I have given gentlemen lessons in turning. Many gentlemen, and some peers, are very good ivory turners. I

gave lessons to a gentleman who had the lathe and all the turning tools and apparatus that old George III. used to work with. It cost £500 at a sale. I have seen some of the old King's turning, and it was very fair. With industry he might have made 40*s.* or 50*s.* a week as a hard-wood and ivory turner." —There is something especially rich in this last-named estimate of kingly labour.

Among miscellaneous manufactures in wood which receive illustration at the World's Exhibition, is that of *cedar pencils.* It is placed before us in an intelligible form by the specimens and apparatus deposited by Mr. Morrell. Here we find, first, the black-lead or plumbago, in the forms in which it is brought from Cumberland, or Germany, or other places; and we see the same substance when cut into thin plates. Cedar-wood, from North America, is shown in various stages, as a veneer, and as bottoms and tops for pencils. We see the machine for cutting the groove in one-half of the pencil, and the half so grooved; the slab of blacklead inserted in the groove, and the machine for bringing it to a smooth even surface; the tops of the pencils separately, and the tops when glued to the bottoms; the machine which rounds the four-sided pencil into a cylindrical form, and pencils in various stages of this rounding process; the tool which finishes the end, and pencils in different stages of finishing; the machine for stamping the maker's name on pencils, and the finished pencils so stamped.

## The Toy and Lucifer Trade of Germany.

The importance which trifles assume when they become grouped in millions, is recognised not only by a well-known Scotch proverb, but by the every-day experience of each of us. *Lucifer-matches* are as good exemplifications of it as anything we might hit upon. What can be more humble than this tiny bit of wood? And yet when we are told that one single saw-mill in London cuts up 400 large timber trees annually into splints for matches, we find that the lucifer mounts to a position of great commercial importance. Many forms of machine are used in this process; but all of them comprise, as part of their mechanism, a system of knives or cutting edges, placed as far apart as the thickness of each splint. In one of these machines, the wood is first cut into quadrangular blocks, which are acted upon by a long range of sharp parallel knives; and these knives work with such rapidity, that 30,000 splints can be cut in a minute! These splints are sold to the match makers, not simply by bundles, but by *hogsheads.* An account has been recorded of a consignment from a London saw-mill to a Bristol match maker, of thirty hogsheads, each containing five hundred bundles, each bundle containing seventy-two boxes, and each box fifty splints. Let the reader calculate the numerical amount of this curiosity of match-making.

The Great Exhibition has not failed to supply us with curious illustrations of the wood-match trade of Germany. In the Zollverein section we find Peter Harass's matches and boxes for matches. The cheapest unadorned match-boxes are sold as low as sixteen silbergroschen per 1000,—rather less than 2*d.* per 100! From this minimum they ascend to five or six thalers per thousand, according to the degree of decoration. Raw matches, two inches in length, un-tipped with composition, are five thalers per 1,000,000; about 1400 for one farthing. This exemplifies what the Thuringian district of Saxony can produce in the match department. Wilhelm Meyer, of Mecklenberg, exhibits bundles of matches made by a machine, which enables him to fashion 300

well-made matches by a single movement of the hand, and 1,000,000 in four hours. He seems to have a method of preparing wood to a semi-charcoal state, if we may so express it; for among his specimens are several pieces of *roasted* wood, six or eight inches in length, intended for quick ignition in furnaces; he has also "smokeless wood," for cigar-lights, about six inches in length.

In the Austrian department we find Fürth's curious collection of Congreve or lucifer matches, made at Shüttenhofen in Bohemia; these quite eclipse our English productions in variety and ingenuity. They are cylindrical, vertical, oblong, hexagonal; some open like a pocket-book, some like a telescope, some like a cigar-case, some like a snuff-box; in some, a mouse is crouching over a recess containing the matches; while in others, General Tom Thumb's head is moveable, and reveals the matches beneath. But M. Fürth does not confine his attention to the plain wooden every-day lucifers: his curious assemblage comprises other light-giving trifles. There are *cigarren-zünder*, or cigar-lights, paper pipe lights, wood splints, boxes of amadou, or German tinder, wax-taper matches, friction shavings, and round thin splints without the tips of chemical composition. The prices of these articles are worth noticing: they are almost fabulous. The cheapest boxes, containing eighty lucifers each, are three kreutzers (about one penny) per dozen; and even "ladies' lucifer matches" are obtainable at seven kreutzers per dozen boxes. A case containing fifty boxes for 100 each (without the lucifers) is ten kreutzers, three boxes for less than a farthing, and the case given in addition. The "round thin wood for lucifer matches" is catalogued at prices which seem to out-cheapen all other cheapnesses: we might suspect typographical error, were there not different entries to balance each other. Bittner, a lucifer maker at Neudorf, in Bohemia, has match splints at 0¾ kreutzer per bundle of 1000, or 2250 for one farthing. But Fürth goes beyond this; he has bundles of 25,000 for five kreutzers, which is equivalent to 3850 for a farthing!

Besides Fürth's and Bittner's collections, there are others from other parts of the Austrian dominions: from Pollak and Preschel of Vienna, from Hoffmann of Wisogzan in Bohemia, and from De Majo of Triesch in Moravia,—all of which illustrate the marvellous price at which these tiny igniters can be sold. De Majo even goes beyond (or rather below) Fürth in cheapness; for he sells "a case of fifty boxes, each containing 100 lucifers," for thirteen kreutzers, about fourpence English!

The same circumstance which enables the Germans to produce cheap lucifers, is also instrumental towards the production of the carvings and the children's toys, which are brought in such immense numbers from the hilly regions of North Germany, Austria, and Switzerland. The forests supply abundance of timber at very low cost; and the peasant mountaineers, simple and frugal, employ their leisure hours, and the time of their children, in fabricating these articles. Dealers are sure to be found, who will drive a trade in these trifles in some country or other. Toys occupy a fitting place among the collections sent to the Great Exhibition. The assortment displayed by Müller of Oberleutensdorf in Bohemia, is among the specimens which illustrate the cheapness of such productions in that country. Some of these toys are made of metal, or have metal in their composition; but for the most part they are of carved wood, packed in chip boxes. Among these, some are catalogued as low as six kreutzers (twopence) per dozen boxes; nay, there are even entries at twenty-nine kreutzers per *gross*, equivalent to about fourteen boxes of toys for one penny! From this minimum, almost inconceivably low

as it is, there is a regular gradation upwards to eighty-four florins per dozen, or 13*s*. 8*d*. per box.

The 'Art-Union Journal' a few years ago gave some curious information concerning the better kind of carved German toys: "The best German toys come from the town of Sonneberg, on the south-eastern frontier of the forest of Thuringia. It has a population of 4000 inhabitants, of which the greater part are employed in the trade. The principal toy merchants, numbering about thirty, provide themselves with goods from many hundred different makers of common articles, resident in the town and its vicinity; these again are furnished by the neighbouring villagers with the requisite raw materials in wood, such as musical boxes, &c., which are fitted up and painted by the makers in the town. Every year about 25,000 cwts. of these goods are exported to almost every part of the world; but the manufacturers are restricted to the use of wood or paste, or these two materials combined. The factory from which the best toys are derived, is that of Adolph Fleischmann, who employs none but first-rate workmen; and it is astonishing to notice the many admirable productions these uneducated artists bring out; models and groupings of figures that would cast no discredit on the atelier of a Baily or a Westmacott."

Children's wooden toys have their political economy as well as more imposing matters. If the peasants of the Black Forest and of Nürnberg can make boxes of "Noah's arks," cavalry soldiers, farm-yards, sheep-folds, skittles, tea-sets, and so forth, cheaper than even the cheap produce of the toy-makers of London, the former will tend to drive the latter out of the market —so says political economy, and so say the practical toy-dealers. The result is, that the London wood-cutters work up their wood into other forms; they make rocking-horses, kites, drums and tambourines, swings, velocipedes, halfpenny carts and halfpenny money-boxes, penny mouse-traps and penny puppet-shows, dolls' houses and dolls' bellows, and knick-knacks, large and small, which it would be no easy matter to enumerate. It seems that the English toy-makers produce the best dissected puzzles, and the best large toys of the rocking-horse genus; the French take the lead in mechanical or clock-work toys; the Swiss command the market for white-wood cottages and models; while the Germans beat all others in well-carved toys, and in the cheap boxes of toys just alluded to. If it were needed to view the politico-economical aspect of wooden toys any further, we might say that the London Gazette and the Stock Exchange price-list are as sensitive barometers to the toy-dealers as to greater men; for if the head of a family finds his worldly affairs not so bright as usual, Dick must go without his new cart or kite, and Polly must wait awhile for her doll's bedstead.

## Wood as a Fine-Art Material.

The carvings just noticed point to a distinct aspect which working in wood presents. It is a material whereon taste and art may find exercise.

The service which *box-wood* renders to wood engravers is due to its hardness, smoothness, and homogeneity of substance. The book-pictures, or picture books of the Chinese are cut in pear-tree wood; and it is probable that this and other woods were used by the early European engravers; but box-wood is almost universally employed at present for this purpose. The surface is brought to a beautiful degree of regularity and smoothness; and a very ingenious mode is adopted of screwing two or more blocks together edge to

edge, to make one block of large size. It is certainly a signal proof of the skill with which this joining is effected, that the large cuts in the 'Illustrated London News,' some of which measure 42 inches by 28, are printed from blocks built up piece-meal with smaller pieces.

*Scorching*, and *pressure*, have both been employed to bring the surface of wood to a pictorial condition. The learned name of *Xulopyrography* ("hot-wood-drawing") has been recently applied to what, in humbler phrase, is called *poker-painting*. When a hot iron is applied to the surface of wood, it chars or scorches the wood wherever it touches; and if the operator possesses artistic taste, he can so manage these charred lines as to give them a pictorial arrangement. There are some specimens of this kind in the Great Exhibition, which display surprising skill; especially where the surface is charred all over, and then *scraped* to produce the picture, as in mezzotint; copies from Landseer's pictures, and other subjects, have been thus produced with much boldness of effect. The production of designs by *pressure* depends upon a singular circumstance; if wood be pressed by suitable instruments, it does not recover its original evenness of surface until it has been steeped in water. The artist produces a sort of design on wood, by strong pressure in particular parts; he planes down the protuberant portions, and then soaks the whole in water; this brings up the pressed, or hardened lines, which thereafter stand up as a sort of bas-relief. It is impossible, however, to produce such effectual results by this as by the charring process.

But it is in carving, properly so called, that wood is chiefly employed as a Fine-Art material.

In minute carving, Greece, Spain, India, and Switzerland, all put forth remarkable specimens in our Exhibition, besides those from the better known European countries. The small carvings from Greece are in a yellowish wood somewhat resembling box, and all relate to sacred subjects; the details are wrought with great delicacy and minuteness—so much so indeed, that in some of the bas-reliefs there are nearly twenty heads within the space of a square inch. In Spain the carvings of a minute kind are chiefly in ivory. The Indian specimens comprise, besides those in ivory, others in sandal-wood, a deep-tinted wood which shows off the minute details of ornamentation to great advantage. The Italian specimens of carving are chiefly in connection with the exquisite Florentine cabinets and tables, before mentioned. As for the carved *cherry-stone*, with its 'St. George and the Dragon,' and its twenty-five Lilliputian heads, we may pass it over as a toy. The Swiss specimens are in a light and soft kind of wood, and the designs are of a light and cheerful character; flowers, foliage, village occupation, herd-keeping, chamois hunting, are among the subjects depicted by the Swiss carvers. It has been said, that "a Swiss peasant takes to carving wood as naturally as ducklings to the pond." In the long winter evenings, in the long summer days, the carvings are in progress, either when no other work can be carried on, or when the carver is simply tending his herd on the mountain sides. Walking staffs, pipes, drinking vessels, forks and spoons, "merry Swiss boys," undaunted William Tells—nothing comes amiss to these Swiss carvers, who contrive to throw a force and expression into all they produce.

How wonderful are the Bavarian carvings from Siegen and Oberammergau! Kiffan's model (for such it is) of Lionardo da Vinci's 'Last Supper' is a truly remarkable production; for it is a carrying out of the great painter's conception from the region of painting to that of sculpture. The model is about

fifteen inches long, six wide, and five high; and all the figures are given in full, or "in the round," with great expression and delicacy. When we find that, even in such a cheap district as the hilly country of Siegen, the artist prices this carving at two hundred thalers, we may readily believe that the workmanship must be very elaborate. The domestic scenes represented in the carvings of Erbel, from the same district, are equally beautiful; they reveal incidents of Bavarian peasant life, and show at the same time how excellently linden or lime-tree wood is adapted for carving.

Among the visitors to the Great Exhibition many have doubtless seen the curious carved ivory balls deposited in the Chinese section. These balls (or others of a similar kind) have been a source of wonderment ever since they were first brought to Europe. How *could* or *did* the little balls get within the outer one? It seems to surpass the presti-digitation even of Robert Houdin himself. We find, in the first place, a most delicately carved and perforated ball, say four or five inches in diameter; within this is another ball, concentric with it, but perfectly detached from it, and carved with a wholly different design; within this is a third, similarly concentric and detached, and having a particular pattern of its own; within this is a fourth, of which a similar character may be given; and so on, to the extent of two or three more gradations. It seems to be generally admitted that the whole are carved from one globular piece of ivory; and the question arises, by what means can the inner carving and the inner severances (so to speak) be effected? All kinds of theories have been started in explanation of the method; but the most generally received seems to be, that the workman must employ *bent* tools, which, after the face of the ball has been cut to a certain depth in certain parts, work laterally. There are some plain specimens in the Exhibition, turned or carved in box-wood by Mr. Mitford, which seem to show that the principle of the method has been mastered in England.

An attempt is being now made (and certainly not before it is needed) to improve the artistic qualities of the carved figure-heads for ships. Many of those now executed are ridiculously poor in conception. Viewed in a right spirit, the figure-head is a symbol of the ship's qualities, or at least might so be made. As the binding of a book might include in its colour and decoration some emblems or symbols of the subject to which the book relates, so might a ship receive a name more significant than those stupid and unmeaning designations often adopted, and the figure-head might be made to carry out the same idea of significancy. But even if the present style of figure-heads were continued, surely a little higher tone of art might be infused into them; the foremost portion of so noble a structure as a ship, the part which boldly fronts the broad ocean and its waves, is worthy of the display of talent and even genius. There is a figure-head in the Exhibition, much superior to the ordinary specimens.

Carving seems to be a favourite kind of art-workmanship among self-taught persons. A story is told of a toll-gate keeper, who, sitting by the fire in his toll-house on a winter's night, with his knob-stick in his hand and his dog by his side, sought to beguile the time by a trial at amateur carving. He began cutting away at the knobbed end of his cudgel; gradually he picked out the form of the dog's head; then, looking closer, the ears, eyes, muzzle, and grisly coat, he caught the expression; and again and again took up the work, and cut and carved and scraped and touched, until it seemed almost as if the very stick-head might of itself play watch-dog at the gate. The new-caught art was never again laid aside, but the turnpike was; for the man became

keeper of a museum, where many productions of his own chisel were admitted.

Many circumstances—a revived taste for mediæval decorations among the number—have led to a great advancement in English carving within the last few years. Since the time of Grinling Gibbons, the names of carvers have seldom found a place in records of fine-art achievements; but such is not now the case. The name of Rogers attached to a specimen of carving is a sort of guarantee of excellence; and there are many other names rising into note. The royal cradle, made of box-wood, is one among many fine specimens by the artist just named, displayed in the Industrial Exhibition; and the names of Perry, Austin, Batsford, &c., are associated with admirable specimens in the same department of art. The dead pheasants, by Waller, show how astonishingly such a material as wood, in the hands of a man of talent and taste, may be made to imitate plumage. The various models of buildings in wood, cork, and pith, though displaying much ingenuity and patience, are too simply mechanical to be treated as carvings, in the sense in which the word is here used.

Machinery is now applied to carving, as to most other mechanical processes. The steam-engine does almost everything but *think;* and if it should one day be employed to work a calculating machine—if the genius of Watt should combine with that of Babbage to work a table of logarithms by a few puffs of steam and a few movements of a piston (more unlikely things have happened within the last few years), we might then almost designate the steam-engine a thinking machine. It is a humbler operation, however, which we have now under notice—that of applying the regular, precise, uniform action of steam-power to assist the carver in effecting those parts of his work which require most cutting and least taste. The patented process due to Mr. Jordan, now extensively at work in producing carvings, of which a considerable quantity in one pattern is required, resembles the sawing and planing machines in this—that the tools are fixed, while the wood is fed or conducted up to it. A pattern of the work to be carved is first modelled by the artist, and afterwards copied by the machine in wood with perfect accuracy, and in such a manner that two or three copies are made simultaneously; the carving thus prepared by the machine is then sent back to the artist, who introduces by hand the finishing touches. The carving machine thus does not exactly supersede the tasteful carver; it is his labourer, employed to effect the rough cutting, which calls for more hand-work than head-work. There is something like a legitimate union of powers at work upon the new Parliament House, where Jordan's machine produces carvings too extensive for Rogers's fingers, and Rogers's hand and eye and mind produce results too tasteful for Jordan's machine.

In the Hyde Park collection we have proofs, furnished by the beautiful specimens exhibited by Mr. Faulding, that fret-work and other ornamental designs can be cut by machine-saws with great nicety and precision.

Sketchy and slight as the descriptions given in this sheet have been, they may yet serve to show how great is now the activity displayed in all the operations connected with working in wood, notwithstanding the rivalry presented by new claimants to public favour.

# CALCULATING AND REGISTERING MACHINES.

We are about to give a popular view of a range of machines, the object of which is to perform some kind of calculating, enumerating, or registering operations: something which imitates the *thinker* rather than the *labourer*, or at least assists the former rather than the latter. In the Great Exhibition there is not a section of the building but yields illustration, more or less direct, of such mechanism.

Among the "Curiosities" which it is the object of this paper to notice, some sort of classification will be desirable. Those contrivances which may with any correctness be called *calculating* or *arithmetical* machines will be first passed in review; while those possessing merely a power of *registry* will come later under notice.

### Calculation: Mental Errors and Mechanical Remedies.

There are circumstances of a very peculiar kind often observable in long and intricate processes of calculation. Men whose minds are strongly bent on this kind of labour, and who are profoundly skilled in it, do yet commit mistakes of a most vexing character, often seriously compromising other operations on which they are engaged. The mind wearies, the attention becomes distracted, the eyes become dim, and the thinker, in spite of himself, ceases to think and act with the same precision as before. Hence arises the query—can wheels and axles, which never tire, be made to think for their master? If they can think at all, or rather if they can imitate the *results* of human thought, they can do this as freshly after twelve or twenty hours as at the beginning; not having the fickleness of volition, their blunders, if any there be, can be calculated and adjusted. It is not surprising, therefore, that the application of mechanism to processes of calculation should from time to time have engaged attention.

It may be interesting to note a few examples of the mental and typographical difficulties felt in insuring accuracy in such matters—the typographical difficulties being, of course, such as occur in printing the calculated results, and not necessarily involved in the calculating processes themselves. It was the necessity of accuracy in scientific tables, and the difficulty of obtaining that accuracy, that led to the conception of Mr. Babbage's celebrated calculating machine. Those who know even a little of science are aware that tabulated numbers enter largely into the working materials of such studies; but it is in astronomy and navigation that this chiefly appears.

Dr. Lardner gave some curious information concerning such tables, in a paper published in the *Edinburgh Review* in 1834. The use of a Numerical Table is to save practical men the trouble of making computations for themselves, by having such computations made once for all, and printing them for the use of those who may be concerned in such matters. The "Ready Reckoner" of a thrifty housewife is often a tabulation of results which she

*could* not calculate if she would; but the "Interest Table" of a banker gives results which he *would* not willingly be left to calculate, though he has the skill to do so. These two qualities underlie all numerical tables: such tables either effect what we cannot, or they save time in that which we can effect. There are *Multiplication* Tables, *Square* and *Cube Power* Tables, *Square* and *Cube Root* Tables, Tables of still higher *Powers* and *Roots*, and others relating to common arithmetic. In Prussia there is a printed Multiplication Table as far as 1000 times 1000. Then there are the various Trigonometrical Tables, such as the Tables of *Sines*, *Co-sines*, *Tangents*, *Secants*, *Arcs*, *Angles*. Another class consists of Tables of *Logarithms*, applied to numbers of various kinds. Then there are the various Tables required by surveyors, architects, engineers, builders, carpenters, gaugers, and others, in the course of their duties. A more special class is that which comprises Tables of *Interest*, *Discount*, *Exchanges*, *Annuities*, *Life Assurance*. But it is in connection with Astronomy and Navigation that Tables are most urgently required; and they are here so numerous that we cannot even give their names.

Now it is in preparing and perfecting such tables that mechanism is believed to be available. Iron is made to think, and to record its thoughts. Under ordinary circumstances both the thinker and the recorder commit blunders which the most sedulous care fails to remove. A remarkable proof of this was given in the preparation of Mr. Babbage's Table of Logarithms by the usual method. After computation, Mr. Babbage's table was compared with those of Callet and Vega, and errors corrected; it was compared again with the tables of Callet, Vega, and Hutton, and further corrections made; the revised sheets were again compared with Vega, Callet, and Briggs; they were then stereotyped, and the proofs compared with the tables of Vega and Gardner, and by two computers with that of Taylor. And yet, even after all this, a few errors were detected in the stereotype plates themselves. Sometimes two or more of the printer's types fall out of their places, and he re-adjusts them as he *thinks* they were before; but if he blunders, it may require a sharp and practised eye to detect the misplacement. No books contain so many *errata* as numerical tables; and it sometimes happens that the erratum itself contains an error. The oddest example of this kind of cross-purposes occurred some years ago in the *Nautical Almanac*, where it was necessary to give an *erratum* of the *erratum* of the *errata* of a particular Table of Logarithms.

One mode of lessening the liability to these errors is to treat the computers themselves somewhat in the light of component parts of one great machine. Perhaps the most remarkable instance of this kind—this treatment of a man as a calculating implement—was furnished by the system on which the great French Tables were prepared. About the year 1792 the French government planned a series of the most extensive mathematical tables ever known; they were chiefly logarithmic and trigonometrical tables, and were intended to assist in the preparation of the decimal system of weights and measures, which has since been introduced in that country. The distinguished savant, Prony, was intrusted with this great work; and he directly saw, that even with the aid of three or four able mathematicians, the whole of his life would not suffice for the completion of the tables. While pondering on this matter, he chanced to light upon a copy of Smith's *Wealth of Nations*, and to open it at the part where the author gives his well-known illustration of the advantages resulting from division of labour. The principle advanced by Adam Smith is, that if a number of men divide a certain amount of work among

them, in such a way that each shall take that which best suits his skill and strength, the work will be better and more quickly done than if all take alike, equal shares and equal kinds. The factory system depends essentially on this principle; and Prony saw that it would also be advantageous to his purpose. He determined to have a sort of mental factory, in which some should think more than work, and others work more than think; by which means he was able to avail himself of a rougher, humbler, cheaper class of assistants than would otherwise be possible.

The plan was thus carried out. Three degrees of mathematical talent were determined—one possessed only by analysts of the highest order, a second possessed by average mathematicians, and a third which involved nothing more than the commonest rules of arithmetic. The three classes may be said to have borne some such relation to each other as architects, master builders, and workmen. The first class was represented by five or six persons, who entered into a profound investigation of various mathematical doctrines and processes, to select those which were most readily adapted to simple numerical calculation by many individuals engaged at the same time. The second class comprised seven or eight mathematicians, who took the instructions given by the great analysts, and brought them into such a form as to be intelligible to; and within the practical scope of, the third. The third class, comprising what we have likened to a calculating machine, consisted of about a hundred persons; nine-tenths of them knew nothing of arithmetic beyond addition and subtraction; they received certain very simple rules from the second class (the reasons for which they were incompetent to understand), and, guided by these rules, they computed the whole of the tables by simple addition and subtraction. Adam Smith's theory was here well borne out; for not only did these humble computers relieve the skilful mathematicians from a wearisome labour, but it was found that they were usually more correct, on account of the uniformity of the work intrusted to them. A similar thing was observed in connection with the great Ordnance Survey of Ireland, where numbers of Irish boys were met with, able and glad to make the simple detailed computations at a *halfpenny a triangle*, more uniformly correct than if computed by higher skilled and higher paid mathematicians.

But it is only in the application of mechanism, of manufacturing industry, to the furtherance of arithmetical calculation, that these matters come properly under notice here. To such applications, therefore, we proceed.

Such mechanical aid as is here alluded to, has been more or less applied in many countries at different times. The *Abacus* of the ancients was a frame, across which a few wires were stretched, and on these wires were strung beads of different colours; each bead represented a numeral, and the rank or order of the beads represented the rank or order of the digits. The original abacus is attributed to Pythagoras, but it is considered that this may have been nothing more than what is now called a *Multiplication Table*. The abacus of beads and wires, just described, was used by the Greeks; the Romans adopted a form in which pins were used for beads and grooves for wires. The abacus used by the Chinese, and called *Schwan-pan*, consists of several brass wires extending from the top to the bottom of a frame, and divided in the middle by a cross-piece from side to side; the beads are so strung on the wires, that each wire has two beads in the upper part and five in the lower; and all the beads have different values assigned to them according to their positions.

A more efficient mode of facilitating the multiplication and division of large numbers, by mechanical means, was invented two centuries and a half ago by Napier of Merchiston, the inventor of logarithmic arithmetic; he called the art *Rhabdology*, and the instrument came to be called *Napier's Bones*. These bones or rods consist of five oblong pieces of wood or any other convenient material, divided each into nine little squares; each square is resolved into two triangles by diagonals; and the numbers of the multiplication table are written in these squares in such a manner, that the 'units' figure is found in the right hand triangle, and the 'tens' figure in the left hand triangle of the same square. It would be difficult, without diagrams, to explain the mode of effecting multiplication by these pieces; but the pieces are ranged side by side, in an order determined by the figures of the multiplicand and the multiplier, and the answer is found at the intersection of a vertical with a horizontal line—in a mode similar to that in which most tables are consulted. Analogous in principle to Napier's bones or rods are the various kinds of *Sliding Rule*, so familiar to engineers and workmen. Whether it be the common Carpenter's slide-rule, Bevan's Engineer's rule, Henderson's double slide-rule, the Excise-officer's rule, the Grazier's rule, or any of those for performing more abstruse calculations, the principle of action is nearly the same —that of placing two or more rows of numbers side by side, and finding the required result at certain junctions of graduated lines.

But these are rather arithmetical *instruments* than *machines;* they are an extension of arithmetical tables; and though it has been said by one who ably advocates the increased use of the sliding rule, that "for a few shillings most persons might put into their pockets some hundred times as much power of calculation as they have in their heads," yet these instruments are not of a kind to call for further notice here. The apparatus invented by Pascal, however, was really a calculating *machine*, and was perhaps the first of its kind. This distinguished man was, in early life, an assistant to his father in an official situation in Normandy; the duties of the office involved much numerical calculation; and young Pascal conceived the idea of shortening the labour by means of a machine. It consisted of a series of wheels, carrying cylindrical barrels, on which were engraved the ten numerals from 0 to 9. One wheel was for 'units,' one for 'tens,' and so on; each wheel was so connected with the one to the left of it, that when the former passed from 9 to 0, the latter was necessarily advanced one figure, or made to rotate one tenth of a complete circle—thus was the familiar process of 'carrying' effected. Multiplication was wrought by a series of additions, and division by a series of subtractions, and the wheels were turned by hand to bring them into the proper relative positions. It is exactly two centuries ago that this machine was constructed; it was distinguished neither for correctness enough, nor quickness enough, to bring it into permanent use; but it contained the germ which has characterised all later machines of the same class. Pascal himself simply spoke of his invention in the following way:—"The arithmetical machine produces effects which approach nearer to *thought* than those which the lower animals produce; but it does nothing which can claim for it the animal power of *volition*." Leibnitz, Grillet, Sir Samuel Moreland, and other ingenious men, invented various calculating machines during the seventeenth and eighteenth centuries; but all these projects have fallen into oblivion.

## BABBAGE'S CALCULATING MACHINE.

Of all machines invented for these purposes, none have approached Mr. Babbage's—in the admirable talent exhibited, in the cost incurred, in the amount of correspondence to which it has given rise, in the time bestowed upon its production, in the mental anxiety which it has caused to its inventor, and in the strange ending of its career.

It was in April, 1823, that official notice was first taken of this marvellous invention, by an application from the Treasury to the Royal Society, for the opinion of that learned body on a plan proposed by Mr. Babbage, "for applying machinery to the purposes of calculating and printing mathematical tables." But the matter was known to scientific persons at an earlier date. Sir Humphrey Davy, the President of the Society, had been familiar with Mr. Babbage's labours; and Mr. Babbage wrote a letter in July, 1822, which was addressed formally to Sir Humphrey, but was intended virtually as a means of making the invention public. He said, "the intolerable labour and fatiguing monotony of a continued repetition of similar arithmetical calculations, first excited the desire, and afterwards suggested the idea, of a machine, which, by the aid of gravity or any other moving power, should become a substitute for one of the lowest operations of human intellect." It may seem strange to many persons so to designate arithmetical processes; but such they really become to men of lofty analytical genius; for, as was before observed, it is found that a mere computer, a man or boy who only knows the first four rules of arithmetic, can compute arithmetical tables more quickly and more accurately than an accomplished mathematician—so much does it assume the character of mechanical routine work, when the exact mode of proceeding is once laid down. Mr. Babbage seems to have contrived, even before that time, many different machines for performing different mathematical operations; they were mostly plans drawn on paper, but one or two had advanced to a working condition.

So early, indeed, as June 1822, Mr. Babbage had read a paper before the Astronomical Society, in which he alluded to the fact that many of the members were acquainted with his views on this subject, and then announced that his labours had attained a favourable result. He mentions certain tables of numbers, and adds—"These, as well as any others which the engine is competent to form, are produced almost as rapidly as an assistant can write them down. The machine by which these calculations are effected is extremely simple in its kind, consisting of a small number of different parts frequently repeated. In the prosecution of this plan, I have contrived methods by which type shall be set up by the machine in the order determined by the calculation; and the arrangements are of such a nature that, if executed, there shall not exist the possibility of error in any printed copy of tables computed by this machine." This is a high character for an inventor to give to his own machine, but there is every reason to think that it involves no exaggeration. In December of the same year, Mr. Babbage communicated a second paper to the same learned body, in which he stated that he had not made any notable progress in his machine, but that he had tested its powers in a singular way. He found that, in considering the arrangements of its parts, a different mode of adjusting them would produce tables of a new species, altogether different from any with which he was acquainted—in other words, the machine could work a problem which

mathematicians could not; he investigated the matter, and, instigated or guided by the machine, succeeded in getting over a difficulty which had perplexed him many years before, in the solution of a problem connected with the game of chess. The machine became a tutor to the machinist.

When Mr. (afterwards Sir T. C.) Colebrooke presented the Society's gold medal to Mr. Babbage, in 1824, he compared the purport of the machine with other mechanical contrivances. "In other cases, mechanical devices have substituted machines for simpler tools or for bodily labours. The artist has been furnished with command of power beyond human strength, joined with precision surpassing any ordinary attainment of dexterity. He is enabled to perform singly the work of a multitude, with the accuracy of a select few, by mechanism, which takes the place of manual labour, or assists its efforts. But the invention to which I am adverting comes in place of *mental* exertion: it substitutes mechanical performance for an intellectual process; and that performance is effected with celerity and exactness unattainable in ordinary methods, even by incessant practice and undiverted attention. The invention is in scope, as in execution, unlike anything before accomplished to assist operose computations. Mr. Babbage's invention puts an engine in the place of the computer; the question is set to the instrument, or the instrument is set to the question; and, by simply giving it motion, the solution is wrought and a string of answers is exhibited. Nor is this all; for the machine may be rendered capable of recording its answer, and even multiplying copies of it."

But, to return to the record of official proceedings, without which the history of this remarkable invention would be unintelligible. The letter addressed to Sir Humphrey Davy having been printed, and a copy sent to the Treasury, it led to the application by the Government to the Royal Society for that learned body's opinion. Men of unquestioned scientific attainments formed themselves into a Committee for investigating the subject. The names of Davy, Herschel, Young, Wollaston, Pond, Kater, Brande, Baily, Combe, Brunel, Colby, and Davies Gilbert, formed this memorable and unequalled Committee; which, thus constituted, after examining the whole subject, reported, "That it appears to this Committee that Mr. Babbage has displayed great talent and ingenuity in the construction of his machine for computation, which the Committee think fully adequate to the attainment of the object proposed by the inventor, and that they consider Mr. Babbage as highly deserving of public encouragement in the prosecution of his arduous undertaking." Mr. Babbage's reason for applying to the Government was, that the full accomplishment of his plans would entail greater expense than his own private resources would bear; and that, as he had no purpose of emolument in view, he applied for national assistance in completing a national benefit. It is said that Dr. Young differed from the rest of the Committee; he thought the invention unquestionably a meritorious one, but he "conceived that it would be far more useful to invest the probable cost of constructing such a calculating machine as was proposed, in the funds, and apply the dividend to paying calculators." However, the Report of the Committee being favourable, the Treasury agreed to take up the subject.

Unfortunately, there seems from the first to have been a want of precision in the mode of conducting the arrangements between the Government and the inventor. In the new palace of the parliament, no one seems to know who has control over the expenditure; and in the far more wonderful calculating machine there was a somewhat analogous train of unsatisfactory

results. Mr. Babbage's first direct negociation with the Government was verbal instead of written, whence arose misconception of the meaning of either party. A few months after the Report of the Committee, the Treasury "directed the issue of £1500 to Mr. Babbage, to enable him to bring his invention to perfection, in the manner recommended" by the Royal Society; but as the recommendation did not lay down any plan, terms, or conditions, the inventor was left to form plans of his own. The machine which had before existed was nothing more than a model; but *the* calculating machine, to be regarded as public property, was commenced by Mr. Babbage in 1823, and its construction continued steadily for four years. Drawings of the most elaborate and delicate kind were made, and skilful machinists were employed to construct the wheels and other mechanism from these drawings. Not only had the best skill to be employed, but workmen had to be educated specially for the work, and entirely new tools had to be invented, so extraordinary was the nicety required in every part of the apparatus. Money was advanced from time to time by the Government, and paid for materials and labour, under the audit of three distinguished engineers—Messrs. Brunel, Donkin, and Field. Mr. Babbage himself received no remuneration for the mental labour and the time bestowed by him on his great work; all went to those who were assisting him.

Years rolled on, and money was advanced from time to time by the Treasury, but the machine was not yet completed; and the House of Commons, the keeper of the public purse, began to exhibit a little restiveness. The Government wished to know how matters were proceeding; and, in December, 1828, a second Treasury letter to the Royal Society was written, begging the Council "to institute such inquiries as would enable them to report upon the state to which the machine had arrived; and also whether the progress made in its construction confirmed them in the opinion which they had formerly expressed, that it would ultimately prove adequate to the important object which it was intended to attain." Up to that time £6000 had been expended on the machine; but neither the inventor nor any one else was able to state how much more would be required. A second Committee was appointed by the Royal Society, in which were the distinguished names of Herschel, Roget, Sabine, Gilbert, Baily, Brunel, Kater, Donkin, Penn, Rennie, Barton, and Warburton. The substance of the Report agreed to by the Committee was, "that the progress made in the machine was as great as could be expected, considering the numerous difficulties to be overcome;" and that the Committee "had no hesitation in giving it as their opinion, that the engine was likely to fulfil the expectations entertained of it by its inventor." The Council of the Society adopted the Report; the Government accepted the opinion given; and more money was advanced.

The Treasury grants, however, became few and far between; and in May, 1829, it became necessary to look clearly at the financial difficulty; A sum of £7000 had by that time been spent on the machine, of which the Treasury had provided only £3000, the rest having been borne by the inventor; and it was found that at least £4000 more would be required. An application was made to the Duke of Wellington, then in office, and £3000 was advanced from the Treasury. Another sum of £600 was afterwards advanced. In December, 1830, the Government made a third application to the Royal Society, which led to the appointment of a third Committee, required to report "Whether the work is proceeding in a satisfactory manner, and without unnecessary expense, and what further sum may probably be necessary for com-

pleting it." The language used by the Committee, after a minute investigation, was nearly an echo of the former reports—admiration of the plans, satisfaction with the progress made, sanction of the financial payments, reliance on the ultimate completion and success—these were the burden of the Report; they recommended that a building should be constructed for the machine near Mr. Babbage's residence; they stated, on the authority of Mr. Brunel, that a sum from £8000 to £12000 would be required to build the structure and to finish the machine; and they proposed that £2000 to £2500 should be appropriated annually. The Government, as before, received favourably the Report of the Royal Society; a building was constructed to contain the machine and the working drawings, and operations recommenced in 1831.

Calamity, however, was at hand. When about £17,000 had been expended, difficulties arose with the machinist who had constructed all the apparatus. He made claims, which were resisted; and, as no compromise could be arrived at, he withdrew all his skilled workmen—and, what was worse, he removed all the valuable tools which had been employed in the work. Mr. Weld, who details these proceedings at some length in his *History of the Royal Society*, says, that this removal the machinist "had a right to do; startling as it may appear to the unprofessional reader, it is nevertheless the fact, that engineers and mechanics possess the right of property to all tools that they have constructed, although the cost of construction has been defrayed by their employers." This was the finishing blow: the works were suspended.

About this time Mr. Babbage was developing the conception of a still more complete machine than that which had caused him so much anxious labour: one that would work mathematical problems of a far higher order. His former one he called a *Difference Engine;* the new one, if the conception should ever be realised, he proposed to call an *Analytical Engine.* He considered that, even if he could obtain his tools and his workmen, it were worth consideration whether to finish the old machine or to begin a better. He applied to the Government on the subject in 1834 and 1835, but nothing was done; he also made his views known to some eminent Italian philosophers. Nine years passed over, from 1833 to 1842; the ins and the outs, in politics, changed places more than once; but no more Treasury grants were made, nor definite arrangements arrived at. In 1842 Sir Robert Peel expressed a disinclination to spend more public money on the machine, but he offered to waive, on the part of the Government, all right of property in it, if it could be completed by private enterprise. Mr. Babbage wished the drawings and the machine to be still considered as public property, and he declined to take them to himself.

Here is, virtually, the close of the history of this wonderful machine; for nothing, we believe, has since been done to forward it. In 1843, on application from the trustees, the Government placed the machine and drawings in the Museum of King's College. The machine is capable of doing a small portion of the work for which it was planned, and this with absolute precision; but the mechanism for its higher powers, and for printing its results, have not yet been constructed. In respect to the second, or *Analytical* Engine, it exists only on paper; yet this paper extends to one hundred large drawings, and four or five hundred large sheets of plans and details—showing the vastness of the enterprise. The extraordinary part of the matter is, that even new tools and new modes of working in metal have to be devised. "A long series of experiments," says Mr. Weld, "have been made upon the art of

shaping metals; and the tools to be employed for that purpose have been discussed, and many drawings of them prepared. The great object of these inquiries and experiments is, on the one hand, by simplifying the construction as much as possible, and, on the other, by contriving new and cheaper means of execution, ultimately to reduce the expense within those limits which a private individual may command."

We have gone connectedly but rapidly through the thirty years' history of this invention—certainly not thirty years of peace to the distinguished inventor; but we have said nothing of its mechanism and mode of action. This is, in truth, no easy matter. To explain the principle on which the machine is based would require mathematical details lying beyond the scope of the present article. It may be stated, however, that the *differences* between numbers in a Table are the elements out of which Mr. Babbage constructs the Table itself; and on this account he calls his apparatus a *Difference* Engine. For instance, in a Table of square numbers, 1, 4, 9, 16, 25, 36, &c., the difference between the first and second is 3, between the second and third, 5; and so we get a series 3, 5, 7, 9, 11, &c. Again, this series of first differences, if viewed in a similar manner, presents us with another and remarkable series, 2, 2, 2, 2, &c. It is found that almost all numerical tables, when thus analysed into successive orders of differences, end at last in a very simple series, constituting the materials—the atomic elements, so to speak—which, by addition, will produce all the numbers required in the table. The process of *addition* lies at the root of the whole method.

Now the question, how to accomplish this by mechanism, was that which Mr. Babbage set himself to solve. The first term of the table, and the first term of each order of differences, being given, the whole table can be constructed from those elements; and dials were made to indicate these numbers. There are rows of dials to represent the successive orders of differences, and rows to represent the successive digits in a number; and, by an extraordinary assemblage of mechanism, the wheels to which these dials are attached act upon each other in an order determined by the original adjustment—by the tune to which this mental organ is set. Each dial has on its edges the set of digits from 0 to 9. There are axes on which the dials revolve; teeth to the wheels behind the dials; bolts which act on or into these teeth; wedges to withdraw the bolts; and shoulders which regulate the action of the bolts on the teeth-wheels—all this determines the process of *addition.* Then there are ratchet-wheels behind the dials; claws which catch in the teeth of these ratchets; hooks which fasten or unfasten the claws; spiral springs which draw back the claws when unfastened; triggers which set the hooks in action; thumbs or studs which govern the triggers; and fingers on the revolving axes which move the claws—all to manage the process of *carrying*, well known to every schoolboy in his addition sums. In the third place, there are rollers resting between curved surfaces; cones resting on conical apertures; and other pieces of mechanism—for *verifying* or ensuring accuracy in the results. Lastly, there are snail-pieces on the axes of some of the wheels; levers to be acted upon by these pieces to ten different heights, according to the numerals; sectors at the other ends of the levers; ten punches in each sector, having the raised character of the ten numerals; a bent lever which acts upon a particular punch in a particular position of the sector; a copper plate on which the punch may make an indented impression; levers for moving the plate while another punch is coming into action—these are for *printing* the results;

or, rather, for producing stamped copper plates, which may either be printed from, or may act as moulds from which stereotype casts can be taken.

Although Dr. Lardner has much skill in describing mechanism, it occupied twenty-five pages in the *Edinburgh Review* for him to describe the action of the calculating machine; and there were some features which he gave up altogether as hopeless, without a mass of diagrams which nobody would look at but practical men. Some of the apparatus and modes of action are indeed extraordinary—none more so than that for ensuring accuracy in the calculated results. If the machine does its work a *little* in error, it is rubbed into good conduct by the friction of adjacent mechanism, on the principle of sympathy which makes pendulums vibrate alike, or men in a mob huzza alike; but if the machine begins to do its work *very* wrongly, the wheels become locked, and refuse to rotate. They will progress rightly, or not at all: they repudiate a slovenly course. This is perhaps approaching as near the region of volition as steel and brass can accomplish.

It was not that all these wonders were produced by the actual machine, or rather model, constructed by Mr. Babbage: but that their possibility and mechanical as well as theoretical correctness were proved by the thousand square feet of drawings prepared by him.

The above details relate, as we have mentioned, to the *Difference Engine*. A few words must be added concerning the younger sister of that contrivance. The *Analytical Engine* seems to embrace within its extraordinary powers, complicated arithmetical operations of an almost unbounded character; and it appears to be the opinion of the inventor, that this engine could not only perform operations beyond the scope of the Difference Engine, but could perform more quickly that which the latter is capable of effecting. An account of the new conception was published in the *Bibliothèque Universelle*, in 1842; and was thence translated (by Lady Lovelace, as stated by Mr. Weld) for Taylor's *Scientific Memoirs*.

For sixteen or eighteen years the Analytical Engine has lived upon paper, and in the fertile brain of its inventor; but as it has not yet assumed the mechanical form, any further notice of it lies beyond the scope of this article. If it ever see the light of day (which every lover of science and mechanical skill would ardently wish), Mr. Babbage must next add an iron labourer to the iron thinker, by setting a steam-engine to work the handle; we could then manufacture arithmetical tables like yards of cotton.

### Recent Arithmetical Machines.

Any comment on the circumstances which have for so lengthened a period rendered the above extraordinary inventions barren of results, besides being painful and unsatisfactory, would lie beyond the scope of the present paper. We therefore propose to take a glance at recent and humbler performances in the same line of mechanical art.

That arithmetical machines of any kind have as yet come extensively into use is more than can be safely affirmed. This is no reason, however, for a suspension of ingenuity on the subject. The regularity and precision of modern mechanism are qualities singularly analogous to those which calculated tables and quantities ought to present; and practical men feel that this analogy will yet produce its good fruit. Ingenious machinists are groping their way in search of these favourable results; and it will be hard if some among them do not hit upon the right path.

Among the English and foreign inventors who have applied their ingenuity in this channel, may be named M. Colmar, a Director of the Sun Fire Office at Paris, who has invented a calculating machine which he calls the *Arithmomètre*. It has been invented more than thirty years, but there appear to have been many improvements recently introduced in it. The claims put forth for the machine are these:—that provided a person knows the numerals, and follows the printed instructions, he can work sums in addition, subtraction, multiplication, division, and square root, without having learned those rules; or that, if he knows them, he may work more quickly and more correctly with than without the apparatus. The machine is contained in an oblong box, from fourteen to twenty-two inches long, according to the extent of its powers. There are as many slides, each working in a groove, as there are places of figures; and each groove is numbered with ten figures, from 0 to 9. There are as many round holes, in a brass plate, as there are possible places of figures in the result to be produced; and beneath each hole may appear any one of the ten numerals. The machine is adjusted to any particular problem, or the "sum is set," by moving some among the many slides; to determine which of the slides, and how far along the groove each shall be moved, depends on the terms of the question; these slides work upon certain wheels and levers underneath, which cause the proper figures to make their appearance at the row of holes in the brass plate.

There is another French machine, by M. Maurel, differing in the working details, but founded on the same principle of graduated sliding bars or rods.

Baranowski's *Ready Reckoner*, lately invented in America, is a much more simple machine than those for arithmetical processes generally. It is intended for questions in which sums of money are concerned; such as days' wages at so much per day, prices at so much per lb., or interest at so much per cent. Let us describe a wages machine. We see an upright box, with a handle at the bottom, rows of figures up the front, and a number of small slides moved by studs. Near the top, concealed within the box, is a paper on which rates of wages are printed, from 1*s*. to 42*s*. per week; there is a small opening in front of this paper, and by turning the handle any required rate of wages between those limits is brought to the opening. Suppose it be 24*s*. per week; then "24*s*." appears at the opening, and the machine is in a condition to show the amount of wages earned in any fractional number of days and hours, at that rate. Let it be four days, five hours; we draw aside a little slide at "four days," and another at "five hours;" these reveal openings, at which appear printed figures representing the sums of money to which the earnings amount. If the time were four days, five hours, and three quarters, three slides would have to be moved, three sums would appear, and these three would have to be added. Whether *time* be saved by this mechanism is a question for each computer to decide for himself. Another application of the machine is for calculating goods tolls at so much per ton; the rate per ton appears at the top, while the tons, cwts. and lbs. appear at the sides, and the result is arrived at on the same principle as in the wages machine. It is obvious that the principle, if useful at all, is capable of wide application.

When we hear and read of Polish Jews, we are apt to think rather of shrewd barterers than of ingenious machinists; yet one of the articles deposited in the Russian department at the Great Exhibition by a Jew of Warsaw, named Staffel, is a highly ingenious mechanical contrivance. It is a machine for

working sums in arithmetic, and is said to perform addition, subtraction, multiplication, and division, with great quickness and unerring correctness; it goes even further than this, for it can calculate powers, roots, and fractions. Externally the machine is small and rather plain, but its internal construction must necessarily be complex. It is an oblong brass box, about four inches high. On the upper face are the words "additio," "subtractio," "multiplicatio," "divisio," ranged in a semi-circle; and to whichever of these an index is turned by a small handle, the machine is then in a state to perform that particular rule or operation. We see seven small holes, with moveable plates beneath them, marked by numerals; seven similar holes in the peripheries of seven little vertical wheels; and thirteen number-holes, if we may so designate them, in another piece of apparatus. Each set of seven holes has a traversing movement, but the longer series is immoveable. The principle of the operation is somewhat as follows:—the two smaller frames are adjusted to the conditions of the question, so as to represent two sums to be added or two to be multiplied, &c., and then, on turning a handle, the answer appears at the thirteen holes of the other frame. Every one of the twenty-seven holes has ten numerals (0 to 9) belonging to it, and any one of these ten may appear at the opening, according to the adjustment for the solution of each question. The machine can multiply seven figures by seven figures (or millions by millions), and can display analogous powers in the other arithmetical processes.

There is one little feature in the machine just described which seems to approach nearer to the volition or judgment of an intelligent being than even the calculating itself. The machine corrects certain errors into which the computer might himself inadvertently fall. For instance, if the machine is set to subtract a larger number from a smaller, or to divide a number by another larger than itself, the machine *cannot* and *will* not do it: it rings a bell, and then stops work. The mechanism by which this singular result is brought about is small but intricate; it shows, however, how many mental processes may, to a certain extent, be imitated by wheels and levers.

Dr. Roth's *Automaton Calculator*, introduced about ten years ago, has the same kind of assemblage of slides, studs, wheels, &c., as characterise most of these contrivances. In one of its forms it simply registers the number of strokes or rotations in a machine, but in its more complete shape it solves questions in addition, multiplication, &c. Analogous in character, too, though differing in details, is the Calculating Machine introduced to the notice of the British Association, in 1849, by M. Slovinski, a Pole; it can perform multiplication sums up to millions multiplied by millions.

## Numbering and Registering Machines.

The reader can hardly fail to perceive that there is a general family likeness among these various arithmetical and calculating machines, however they may differ in details. Instead of further amplification on this point, therefore, we will talk awhile of another class of ingenious contrivances, wherein a principle of *registry* is involved. By this principle a piece of apparatus not only performs its destined work, but preserves a record of the *quantity* of work done: it is an accountant as well as a workman.

One of the French machines at the Great Exhibition is called the *Timbre Additioneur*. It is intended for stamping, and numbering and registering the articles stamped. Different stamps or dies may be used in the same machine,

and exchanged at pleasure. It is intended for numbering and stamping such documents as bills, letters, share certificates, &c., and is designed for the use of bankers, railway companies, the Stamp and Post Offices, and such like establishments. The machine, in its ordinary form, presents a flat table or stand, with a vertical box at the back of it. Within this box are wheels acting one on another, and at the top are dials to indicate how many times the wheels have revolved. A lever projects from the front of the machine, to which is attached the die or stamp. A small inking table is provided; and the lever has a range of movement given to it, which enables the die to be brought down first on the ink and then on the paper to be stamped. As many times as this movement occurs, so many are the revolutions or movements made by the wheel-work; and the index hands show this result on the dial faces. The machine seems to be capable of counting in many different ways, when the stamping part of the apparatus is removed and a few adjustments are made; it may count the passengers through a turnstile, or the revolutions of a coach wheel, or the length of yarn spun by a machine, or that of cloth woven by a loom, or the revolutions of a fly-wheel or of a water-wheel.

Many a curious knot of persons, who have assembled round the Paging Machine at the Exhibition, have there had an opportunity of witnessing an analogous principle at work. There is a handle or lever, an inking apparatus, and a train of wheels with raised numbers on their edges. When the lever is pressed down, one of the numbers comes in contact with the ink, and then with the paper; and on raising the lever-handle the number-wheels are moved round a small space, so as to present a new number for the next inking and printing process. The variations of this exceedingly pretty operation are numerous.

M. Baranowski's ticket-printing, numbering, and registering machine, is a contrivance displaying considerable ingenuity—much more so than his Ready Reckoner. A number of blank cards are placed in the upper part of the machine; a handle is turned, and forthwith the cards make their appearance, one by one, at the bottom of the machine—*printed* from an adopted form, *numbered* from 1 to 2000 or more, consecutively, and leaving a *registry* as they quit the machine. This, it is said by the inventor, can be done at the rate of 5000 per hour. The printing may be in one or two colours, and may be quickly adjusted to any desired form. All this is effected by a machine comprised within the limits of twelve inches long, nine wide, and eight high. The mechanism displays much cleverness. The types are arranged on the circumference of small wheels, placed vertically; and on pressing down the frame which contains the wheels, by a sort of piston or plug, the types come in contact with paper or pasteboard placed beneath; but before doing so, the movement causes a tiny inking roller to work quickly over the face of the types, and thus enable them to print their impress in black ink. If this were all, every ticket would be printed exactly alike; but by means of cogs and notches, and ratchets, the type-wheels make part of a revolution after each impression, so as to present a new figure for the next movement. If the tickets are printed in two colours, there must be two inking rollers, one for each. So much nicety is there in the mechanism, that each machine, small as it is, costs about a hundred guineas.

Another apparatus of somewhat analogous character, is Edmondson's Railway Ticket Machine, extensively used by railway companies. It consists of a series of wheels, together with a stamping and cutting instrument. The pasteboard material is introduced; it is cut, printed, numbered, dated, regis-

working sums in arithmetic, and is said to perform addition, subtraction, multiplication, and division, with great quickness and unerring correctness; it goes even further than this, for it can calculate powers, roots, and fractions. Externally the machine is small and rather plain, but its internal construction must necessarily be complex. It is an oblong brass box, about four inches high. On the upper face are the words "additio," "subtractio," "multiplicatio," "divisio," ranged in a semi-circle; and to whichever of these an index is turned by a small handle, the machine is then in a state to perform that particular rule or operation. We see seven small holes, with moveable plates beneath them, marked by numerals; seven similar holes in the peripheries of seven little vertical wheels; and thirteen number-holes, if we may so designate them, in another piece of apparatus. Each set of seven holes has a traversing movement, but the longer series is immoveable. The principle of the operation is somewhat as follows:—the two smaller frames are adjusted to the conditions of the question, so as to represent two sums to be added or two to be multiplied, &c., and then, on turning a handle, the answer appears at the thirteen holes of the other frame. Every one of the twenty-seven holes has ten numerals (0 to 9) belonging to it, and any one of these ten may appear at the opening, according to the adjustment for the solution of each question. The machine can multiply seven figures by seven figures (or millions by millions), and can display analogous powers in the other arithmetical processes.

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The reader can hardly fail to perceive that there is a general family likeness among these various arithmetical and calculating machines, however they may differ in details. Instead of further amplification on this point, therefore, we will talk awhile of another class of ingenious contrivances, wherein a principle of *registry* is involved. By this principle a piece of apparatus not only performs its destined work, but preserves a record of the *quantity* of work done: it is an accountant as well as a workman.

One of the French machines at the Great Exhibition is called the *Timbre Additioneur*. It is intended for stamping, and numbering and registering the articles stamped. Different stamps or dies may be used in the same machine,

and exchanged at pleasure. It is intended for numbering and stamping such documents as bills, letters, share certificates, &c., and is designed for the use of bankers, railway companies, the Stamp and Post Offices, and such like establishments. The machine, in its ordinary form, presents a flat table or stand, with a vertical box at the back of it. Within this box are wheels acting one on another, and at the top are dials to indicate how many times the wheels have revolved. A lever projects from the front of the machine, to which is attached the die or stamp. A small inking table is provided; and the lever has a range of movement given to it, which enables the die to be brought down first on the ink and then on the paper to be stamped. As many times as this movement occurs, so many are the revolutions or movements made by the wheel-work; and the index hands show this result on the dial faces. The machine seems to be capable of counting in many different ways, when the stamping part of the apparatus is removed and a few adjustments are made; it may count the passengers through a turnstile, or the revolutions of a coach wheel, or the length of yarn spun by a machine, or that of cloth woven by a loom, or the revolutions of a fly-wheel or of a water-wheel.

Many a curious knot of persons, who have assembled round the Paging Machine at the Exhibition, have there had an opportunity of witnessing an analogous principle at work. There is a handle or lever, an inking apparatus, and a train of wheels with raised numbers on their edges. When the lever is pressed down, one of the numbers comes in contact with the ink, and then with the paper; and on raising the lever-handle the number-wheels are moved round a small space, so as to present a new number for the next inking and printing process. The variations of this exceedingly pretty operation are numerous.

M. Baranowski's ticket-printing, numbering, and registering machine, is a contrivance displaying considerable ingenuity—much more so than his Ready Reckoner. A number of blank cards are placed in the upper part of the machine; a handle is turned, and forthwith the cards make their appearance, one by one, at the bottom of the machine—*printed* from an adopted form, *numbered* from 1 to 2000 or more, consecutively, and leaving a *registry* as they quit the machine. This, it is said by the inventor, can be done at the rate of 5000 per hour. The printing may be in one or two colours, and may be quickly adjusted to any desired form. All this is effected by a machine comprised within the limits of twelve inches long, nine wide, and eight high. The mechanism displays much cleverness. The types are arranged on the circumference of small wheels, placed vertically; and on pressing down the frame which contains the wheels, by a sort of piston or plug, the types come in contact with paper or pasteboard placed beneath; but before doing so, the movement causes a tiny inking roller to work quickly over the face of the types, and thus enable them to print their impress in black ink. If this were all, every ticket would be printed exactly alike; but by means of cogs and notches, and ratchets, the type-wheels make part of a revolution after each impression, so as to present a new figure for the next movement. If the tickets are printed in two colours, there must be two inking rollers, one for each. So much nicety is there in the mechanism, that each machine, small as it is, costs about a hundred guineas.

Another apparatus of somewhat analogous character, is Edmondson's Railway Ticket Machine, extensively used by railway companies. It consists of a series of wheels, together with a stamping and cutting instrument. The pasteboard material is introduced; it is cut, printed, numbered, dated, regis-

tered, packed, and sorted, with surprising quickness and accuracy—indeed it *must* be accurate; for such a machine could not act at all unless its various movements succeeded each other in proper order.

The same general principle lies at the root of many instruments patented or introduced within the last few years. Thus, Mr. Lewthwaite's machine, invented in 1847, and intended for numbering railway or pawnbrokers' tickets, or paging books, or for printing any consecutive series of numbers, has its type-wheels and driving-wheels, its levers and studs, and other complex mechanism; but there is still the movement of a wheel one-tenth of a revolution after each pressure, and other wheels which revolve each one-tenth as fast as its neighbour.

A wider extension is given to the use of such machines when they are individually simpler in action: that is, they are applicable to a greater number of purposes. Suppose, for instance, it be merely to record the number of times that a certain operation is conducted, without any printing or stamping process, we have at once an instance in a contrivance for which Mr. Whiffin obtained a patent a year or two ago. It comprises toothed-wheels, ratchets and ratchet-wheels, a dial plate, and index hands; and it is intended to be applied to the trap-door of a ship's coal-weighing machine, to register the number of times that the door of the shoot has been opened for the discharge of coals. Supposing the apparatus to be effective, a slight modification would enable it to register the filling of measures of grain, or the number of times that a porter or carrier has crossed a plank with goods.

It may very safely be doubted whether anything so delicate as galvanic apparatus would bear the rough usage of omnibuses and cabs; otherwise the *theory* of Mr. Pownall's "Patent Register" may be sound enough. The object of the apparatus is to place a check upon money-takers in public vehicles, or at the entrance of theatres, bridges, piers, and public gardens. As applied to an omnibus, a small galvanic battery and a registering apparatus are placed under the floor of the carriage; every time a person treads upon the step, a galvanic circuit is established with the battery; and, by a train of wheel-work, an index wheel is made to revolve to the extent of one tooth or notch. By this means, as many notches are traversed as there have been persons enter the omnibus; or rather, as the exit as well as the entrance of a passenger marks one notch, the actual number is doubled. There is a numbering dial, on which an index hand shows the result. Whether a pair of omnibus servants could "drive a coach and six" through such a contrivance, we would not venture to predict.

Mr. Walker's *Operameter*, invented several years ago, was intended by him to measure or register the amount of work performed by certain machines in the woollen manufacture. The apparatus had a shaft which could be connected with the gig-mill, the shearing machine, or other machines employed in that department of industry; this shaft necessarily rotated as fast as the machine to which it was applied; and the shaft gave motion to a train of wheel-work, with a dial face and index hands to denote the number of revolutions made in a given time. The index hand thus became a measure and recorder of the amount of work done.

To register the height of the tide at tidal harbours is also among the valuable services which self-acting tell-tale machines are fitted to render. Let us take the Sunderland Tide Gauge as an example. Here there is a vertical tube into which the water rises to a height depending on the

height of the tide. On the surface of this column of water is a light float, which rises and sinks with it; a copper wire from the float rises upward to a train of wheels and rollers, which rotate in one or other direction, according as the float rises or sinks. From one roller to another passes a web of wire gauge, on which are printed in large characters the various depths from high to low water; and two fixed pointers or hands also show the number of feet and half-feet of depth of water, at any hour of the tide, on the bar at the entrance of Sunderland Harbour. There are thus rendered visible, to those most nearly concerned, and at all hours, the height of the tide and the depth of water on the bar. But this instrument leaves no permanent record behind: it *indicates* but does not *register*. There are other tidal-gauges, however, which render this further service. The construction of such instruments is somewhat as follows:—We will imagine there are the tube, the rising and falling column of water in the tube, and the float on the surface of the water; we must also suppose there is a cylinder, having regular motion given to it by clock-work, and having its surface covered with paper ruled in a particular fashion. There is a wire extending from the float to a rack which holds a pencil; and this pencil presses against the paper. Now the result of this arrangement is, that the pencil marks a line *round* the cylinder as the latter revolves, and *along* the cylinder as the tide rises or falls; so that the exact height at every and any period of time is permanently registered.

The registering meteorological and philosophical instruments have now become a very numerous and varied class. They put in a permanent form the record of the information which they convey. Heat, moisture, barometrical pressure, rain, wind—all now register the times and quantities of their occurrence. Let us illustrate this by one example. Mr. David Napier patented an ingenious barometer in 1848, intended to mark the variation of atmospheric pressure throughout an entire period of twenty-four hours. Connected with the barometer tube is a vertical spindle, which carries a card having on its surface a number of radial lines and concentric circles; the radial lines represent fractions of inches, and the concentric circles represent portions of time. Above the card is a lever carrying a vertical pricker, which is made to rise and fall at certain regular intervals of time, and to travel from the inner concentric circle to the outer one once in twenty-four hours. On the vertical spindle, and underneath the card, is fastened a grooved wheel, round which is passed a cord; a counterbalance weight is attached to one end of the cord, while the other end is made fast to a float resting upon a column of mercury in a tube. The card has a fixed point representing 29·5 inches, which, at commencement, is placed underneath the pricker. As the column of mercury rises or falls by the varying pressure of the atmosphere, the printed card will travel to the left or the right accordingly; and the variation of height will be indicated by the distance of the punctured lines from the starting point, on either side.

## Registry of Time, Space, and Speed.

Many curious varieties, in the machines which register or tell their own tale, are presented by those whose duties are related more or less to *time*, *space*, and *speed*. In one case it is the speed of a pedestrian, in another that of a carriage, in a third that of a locomotive; a fourth attends rather to the total distance travelled, than to the rate of progress; while another kind registers the time which has elapsed between two events, without attending

either to space or to speed. A few examples, taken at random, will illustrate the sort of machines here kept in view.

Travellers are from time to time reminded in the usual sources of information of the merits and uses of "Payne's Pedometer, for the waistcoat pocket." It is a small but ingenious distance measuring and registering machine, about the size and shape of a watch. The action is very peculiar. Every one knows that each step of a pedestrian, or of a horse jogging at regular speed, is accompanied by a sudden jerk, or sinking; and it is the series of these jerks which the machine registers. There is a small lever, with a pivot at one end and a weight at the other; this is so nearly balanced, that the slightest movement causes it to sink, and the steps of the pedestrian thus keep the lever in regular and steady oscillation. There is a small assemblage of wheels, pinions, and dials, by which the number of oscillations is registered; and this number multiplied by the length of pace, or step, gives the total distance walked over in a given time. By a little ingenious adjustment, the instrument is rendered applicable to carriage travelling.

The somewhat too learned names of *centimetral chronometer*, and *velocentimeter*, are given by Mr. Whishaw to an apparatus recently invented by him. The velocity with which a railway train is moving is the element to be determined by this machine. There is a dial-face connected with a clock, and a ring surrounding the dial; this ring is graduated to quarters of a mile if for use in England, or to some aliquot part of a kilomètre if for use in France. The zero mark on the ring is brought opposite to the index-hand on the dial, at the commencement of the period during which the velocity is to be determined, which should be when the train is opposite one of the mile-posts; then, on arrival at the next post (on English railways these posts are a quarter of a mile apart), the index hand and the zero point will be found to have separated, and the amount of this separation furnishes the means of determining the velocity of the train.

Belonging to the same family of machines, though produced in a different country, is M. Redier's *horographe*. Whether this apparatus has been brought into practical use on the French railways, we do not know, but the inventor seems to have aimed at a very complete range of registry movements. The object is, to trace the progress of a railway train throughout its whole course. There is one machine which tests the speed of the locomotive. Let the engineer determine the speed, the number of miles or kilomètres per hour, at which the locomotive is intended to travel; he puts a stud into one of eleven holes, which are marked from twenty to two hundred and forty turns of the driving wheel per minute, and he thus notifies one of eleven different rates of speed. If the required speed is kept up, an index hand maintains a vertical position; if the speed is too great, the index turns to the right; if too slow, a reverse movement takes place. There is another apparatus which prints on a sheet of paper the exact time of arrival at each station. France has also produced an ingenious machine, by a different inventor, we believe, which is busily employed while the train is in motion. A sheet of paper is placed in an oblong box; and on this paper is indicated once a minute, and also at the completion of each kilomètre, the speed and the distance travelled; it also shows the time of arrival, and the duration of stoppage at each station.

In one sense almanac clocks may be included among registering machines. By these we mean those complicated watches, clocks, and chronometers which indicate so many astronomical phenomena. For many centuries, and in many countries, these specimens of ingenuity have been produced. They are

mostly, however, little more than toys, for the slightest derangement (and derangement is very likely to occur among such small and intricate mechanism) will affect all the phenomena at once; and eclipses will fail to appear (as eclipses are wont to fail in cloudy weather) at the proper time. It is impossible to walk through our Great Exhibition without meeting with numerous specimens of this class—chiefly in the French clock department. One of the prettiest examples is a chronometer about three inches in diameter, the face of which contains dials enough to indicate twelve different phenomena respecting seconds, minutes, hours, days, months, sun-rise, moon's age, moon's phases, &c.

The *Liverpool Albion* announced a few months ago, that Dr. Henderson of that town had been engaged, since 1844, in producing a chronometer which would excel everything of the kind ever made. If the announcement be one half true the instrument will be indeed a marvel, and society will be eager to welcome it when finished. According to this account, the clock will show the minutes and hours of the day; the sun's place in the ecliptic; the day of the month perpetually, and take leap-year into account; the moon's age, place, and phases; the apparent diurnal revolution of the moon; the ebb and flow of the sea at any port in the world; the golden number, epact, solar cycle, Roman indiction, Sunday letter, and Julian period; the mean time of the rising and setting of the sun on every day of the year, with its terms, and fixed and moveable feasts. The day of the week will also be indicated, and the year will be registered for 10,000 years past or to come. The quickest moving wheel will revolve in one minute, the slowest in 10,000 years. Furthermore we are told that there are 170 wheels and pinions, and that the machine will go 100 years without winding up.

Mr. Carey's measuring machine is one among numerous examples of this kind. It is intended to record the number of revolutions made by the wheel of a carriage. The apparatus is very small, and is buckled by straps to one of the spokes of the wheel near the nave; it of course follows the curved course of the part of the wheel to which it is attached; and once in each revolution it causes a wheel to be advanced one tooth; so that the number of teeth advanced determines the number of revolutions made by the wheel. It was a contrivance something like this in principle, though differing in details, which James Watt devised for registering the number of strokes of a steam-engine.

The *turnstiles* at the Crystal Palace, at the ends of toll-paying bridges, and at the entrances of many public buildings and exhibitions, are excellent examples of registering apparatus. The older method of testing the honesty of money-takers was by issuing tickets or checks, the return of which would show how much money had been received; this plan is still adopted at the theatres; it requires two servants instead of one, and is not proof against collusion. Now, in the mechanical turnstile, the instrument preserves a record of the number of times it has turned on its axis; and the money-taker must be prepared to account for a sum of money corresponding to the number. Some of the precautions protect the money-taker against the public, while some protect the proprietors against the money-taker. In the first place, there is a vertical framing, capable of rotating on a vertical axis; it can only rotate in one direction, and only one person can pass it at a time. The framing or turnstile cannot rotate at all until the money-taker presses his foot on a lever; and directly the passage is made, the lever is allowed again to drop, and the turnstile is locked. This movement causes a movement in a

toothed wheel to an extent of one tooth; and, as this registering apparatus is beyond the reach of the money-taker, he has nothing less to do than to account for money to the extent of the number of wheel-teeth which have been moved.

The *Tell-tale* class of machines are more or less complete, according as they *register* the information they give. An *alarum* is a tell-tale, so far as the emission of sound is concerned; but the sound goes off in empty air, and leaves no record behind. Where a night guard, policeman, or watchman is required to show that he has been vigilant in his rounds or watchings, he must leave a record of his presence at a particular spot at particular intervals. A very ingenious mode of effecting this is by M. Aréra's *Pendule Indicateur*, or Tell-tale Clock. It is used by the night police on many of the French railways, and in many public establishments where vigilant guard is required. Let us suppose that a guard or policeman, be his duties what they may, is required to show that he was at a particular spot every quarter of an hour during his night patrol; a sort of table-clock is placed at that spot, and at intervals of a quarter of an hour he presses his finger on a button or stud, which is the only part of the apparatus at his command. Beyond this, he knows or does nothing in the matter; but when the clock-case is opened next day by a superintendent, a circular graduated card is found to be pierced with as many small holes as the guard had made pressures on the stud; and the card also shows the exact hour and minute when each hole was pierced. The mechanism is very simple; the circular card or paper is made to rotate by connection with the hour-wheel of the clock, and the button or stud acts upon a sharp needle which pierces the card. If the card is *not* pierced opposite a particular quarter of an hour, the conclusion is drawn that the guard has failed in vigilance.

Of the tell-tale varieties of apparatus, as used in this country, they may be generally characterised as particular applications of clock-work. Take, for instance, Messrs. Smith's *Detector Clocks*, one of which has been placed in the Great Exhibition. This apparatus has been used for some years in Coldbath Fields Prison, to register the punctuality (or otherwise) of the night-watchman. The registering apparatus consists of a revolving circular frame, fitted with springs and pins; the watchman is required, at certain intervals of time, to touch a little piece of mechanism which preserves a record of his presence. The principle is obviously nearly analogous to that noticed above.

### Registry-Balances: Gold-weighing Machines.

There are some kinds of balances which show much elegance of action, inasmuch as they not only determine the weight of commodities, but either preserve a record of that weight, or separate into different parcels those which differ ever so minutely in weight. The common weighing machines, whether having a dial-face and index-hand or not, do not register permanently the result obtained; as the indications are destroyed directly the weighed commodities are removed. There are contrivances, however, in which, either by a train of wheel-work, or by a pencil passing over paper, the apparatus preserves its own record.

But the exquisitely delicate *gold-weighing* machines are those which are more particularly intended to be brought under notice here. One such is Mr. Kershaw's *Micrometer Sovereign Balance;* it was registered about the year 1842, when the Bank regulations respecting 'light gold' attracted so much

Baron Seguier's Gold-weighing Machine, a specimen of which has been placed in the Exhibition, and which is priced by the makers at 4000 francs (£160), is a somewhat complicated piece of apparatus. It presents to view a sort of vertical wheel, with a hopper or receptacle to feed the wheel with coins; there are two channels from the bottom of the wheel, along which the coins proceed to certain levers and balances. The action of the machine is somewhat as follows:—The coins are put into the hopper, and a range of pins on the edge of the revolving wheel causes the coins to separate into single file, and to descend one by one to a stage below. If the coin be of current weight (which must be determined for each country, and the machine arranged accordingly), there is nothing to prevent it from sliding down an inclined trough into a particular box or receptacle. But if the weight be either over or under the proper limit, the coin is ingeniously driven aside, to the right or the left, according as the weight is too great or too small. This is cleverly managed: the coin falls upon a balanced beam, which remains horizontal if the weight be correct; but if the beam be thrown out of balance by a light or a heavy coin, one of two little studs is raised, which guides it into its proper receptacle. Thus the coins become separated into three groups, merely by turning a handle.

The Indian coin machine, designed by Captain J. T. Smith for the Calcutta government, is larger than that of Seguier, and is intended for weighing rupees. There are ten levers, with a small cylinder suspended from the short end of each: these cylinders dip into distilled water. Ten coins are placed in scales at the long ends of the levers, one to each lever; and according as each coin is heavy or light, so will it raise the cylinder at the other end of the lever, more or less out of the water. If we suppose that the coins are so badly made as to exhibit ten different degrees of error, whether in excess or deficiency, and if the machine be constructed with minute accuracy, then the ten little cylinders would be raised to ten different heights out of the water, and ten groups of coins would be established. Unless the workmanship be very delicate, this method must be of doubtful correctness.

Mr. Cotton's machine seems, by general consent, to be deemed the most delicate ever yet constructed for weighing gold coin. Its precision is, indeed, most exquisite. If ever a "well-balanced judgment" could be an attribute of steel and brass, we have it here: a child can turn the handle, but the machine judges for itself.

In the transactions between the Bank of England and the public, the weighing of gold coin has been a most anxious and tedious process. As between the Bank and the Mint, the labour is not so minute; for 200 sove-

reigns being first accurately weighed, all the rest are weighed in groups of 200. The Mint officers are allowed a deviation of twelve grains in about fifty sovereigns; but they generally work to within half of this amount of error; and if the groups of sovereigns are correct within the prescribed limits no closer weighing is adopted. In the transactions between the Bank and the public, however, matters must be treated in more detail. It is no satisfaction to Smith to know that, if his sovereign is light, Brown has a correct one and Jones a heavy one, so that therefore the Bank is just in the aggregate; each one demands that *his* sovereign should be of proper weight. Hence arises an important part of the daily routine at the Bank. Mr. Cotton was led to the conception of his beautiful machine by observing the injustice which the Bank sometimes unconsciously inflicted on its customers. Sovereigns which were issued from one counter at the Bank as being of full weight, were refused at another counter as being light. The scales may not have been equally delicate, or the liability to error on the part of the weighers (the "personal equation," as astronomers would term it) may not have been exactly equal. An expert weigher could weigh about 700 sovereigns in an hour by the old balance; but the agitation of the air by the sudden opening of a door, the breathing of persons near the apparatus, the fatigued state of the hand and eye of the weigher—all led to minute errors.

Mr. Cotton having determined on the plan of a machine which should be quicker, easier, and more exact than the ordinary gold balance, procured the services of Mr. Napier to put his views into a practical form; and the result is entirely satisfactory. The machine is a pretty, delicate, light affair—much more so than those hitherto noticed. There is, in the first place, a small vertical tube, in which a pile of twenty or thirty sovereigns is placed, in single column. The lowermost sovereign rests upon a moveable plate; when a handle is turned by the attendant, the plate moves sideways, and the sovereign is brought upon an exquisitely sensitive balance; if the weight is correct, a little lever, arm, or pusher, gives the edge of the sovereign a smart impulse, and drives it off into a box; but if the weight be deficient even in the most minute degree, another pusher attacks the sovereign on a different side, and drives it into another box. As the handle is continued in motion, two or three sovereigns may be in different stages of the weighing process at one time. Those who have seen this machine at work at the Great Exhibition may well marvel at the delicacy with which the movements of the sovereign are controlled.

As the Bank of England does not take cognizance of gold coins which are *too* heavy (perhaps the Mint authorities do not give them occasion for so doing), this machine merely separates sovereigns into two groups, the *full* and the *light;* and it does not indicate by how much the light sovereign is deficient. It is therefore only by actual trial that the delicacy of the machine has been tested; if a difference of even a hundredth of a grain existed between two sovereigns, it is said that this machine would detect it. On a rough average, 30,000 sovereigns pass over the Bank counter every day; each machine can weigh 10,000 sovereigns in six hours; and there are six machines; so that the Bank can weigh all its issues of gold by these means, and have reserve power to spare. One of the machines is adjusted for half-sovereigns. Between 1844 and 1848 there were forty-eight million gold coins weighed by these machines at the Bank; and the bankers and private persons place undoubting reliance on the correctness of the process. Each machine requires an hour's cleaning once a week; the machines cost about £200 each, and are

said to be peculiarly free from liability to disarrangement. Besides satisfying the Bank, the bankers, and the public, these machines save £1000 a year to the Bank in weighers' wages.

### Miscellaneous Contrivances for Registering.

There are many other little registering contrivances on which we would gladly say a few words; and as it is difficult to class them in any particular way, we will make use of the ever-convenient designation "Miscellaneous."

How to register votes at a division is a problem that has not much troubled our House of Commons; but the National Assembly of France has deemed it expedient to introduce a *Voting Machine* for this purpose. This machine seems to answer two ends—it prevents tampering with the ballots or voting plates, and it enables the numbers on either side to be added up with great ease. In the House of Commons the "ayes" have it, or the "noes," according to circumstances; but in France the system of the ballot is adopted —the relative advantages of the two methods we need not touch upon. The National Assembly has recently voted 30,000 francs for the apparatus of the voting, or rather vote-registering machine now under notice. The whole operation is exceedingly curious, and worth detailing.

In the first place, at the commencement of each sitting, or when the members enter the chamber, each member has given to him a small box, containing ten ballots or voting plates. These ballots are oblong slips of thin steel, about two inches long, and pierced with a hole in the centre; five are white steel for the "pour" or "aye" vote, and five are blue steel for the "contre" or "no" vote. Each ballot is inscribed with the name of the member, and also with a number attached to that member's name in the register of the Assembly. Each ballot has also certain notches on the edge, but the blue ballots are differently notched from the white. The members have thus materials for five votes during the same evening, and for choosing their side in each vote.

Next we have to look at the Voting Urn or Machine. This is a kind of upright box, held by a handle like that of a pewter measure; it is made of wood, and is about three inches square by a foot in height. The right-hand half is painted blue, the left-hand white. At the top are two funnels or mouths, opening into the interior, painted white and blue respectively, and marked with P and C for *pour* and *contre*. Each funnel is grooved in pattern with the ballot-notches, so that a blue ballot can only descend the blue funnel, and a white ballot the other. In the interior, below each funnel, is a vertical stem or staff, on which the ballots become threaded, one on another, as they fall into the urn: the stem being of similar shape to the oblong hole in each ballot.

Now for the process of collecting the votes. The National Assembly is divided into twelve sections; and there are twelve voting urns, each marked with the number of a section. When a debate is concluded, and the votes are to be taken, the twelve urns are taken by an equal number of persons, who go round to the members where they are seated. Each member selects a blue or a white ballot from his box, as he pleases, and drops it into the proper funnel of the urn; he cannot put in two if he would, nor could he, either inadvertently or by design, introduce a ballot into the wrong compartment. The urns are taken to the president, and placed all in a row on a table. By a little adjustment each urn or box is lifted off, and displays the ballots

threaded on the two upright stems; and by a curious contrivance the same movement *locks* the ballots on the stem. By the side of each stem is a graduated scale, which enables the scrutineers to tell in an instant how many ballots there are in each pile. When the numbers are declared, the locked piles of ballots are taken to another room, where they are unlocked, and the vote of every individual member registered in a book. The ballots are then distributed (as a compositor would distribute his type), and each member's set is laid apart by itself for use on another evening. All this *reads* somewhat intricate and tedious; but the Assembly seems to be satisfied with the contrivance, as being an advance on the former system.

The *distribution of type* has just been alluded to; and we may here remark, that Type Composing Machines can, in a certain sense, be considered registering machines, for they leave a record of the work done in the rows of arranged type. In M. Sörensen's remarkable Danish invention for the same purpose there is a nearer approach to what we may designate mechanical thought; since the types, after being used, distribute themselves on merely turning a handle; and not only so, but place themselves in the proper position in the composing machine. The consideration of this matter, however, lies somewhat beyond our present purpose.

Those curious specimens of mechanical ingenuity, *locks*, were briefly alluded to in a former paper, as illustrative of the spread of the iron manufacture; and we might similarly learn a lesson from them in relation to our present subject. Many of the best locks are *registers:* they are recorders or tell-tales of any attempts made to pick them, whether successful or unsuccessful. There is, in such cases, some small piece of mechanism or other which becomes displaced whenever the lock is tampered with; only its own key can open it, and when other keys or other implements are used, they produce some damage or displacement which remains as a record of the fact. There is something, too, in the *permutation* locks, which imparts to them a little of the character of calculating machines—not sufficiently so, however, to need any further notice here. We may well understand how the famous locksmiths of the day would regard the successful picking of their intricate locks. The American artizan who has given so bold a challenge, and undertaken so bold a task on this point, has many anxious and critical eyes upon him.

Electro-telegraphy involves much of the registry principle. This may be illustrated by an example. By Mr. Bakewell's ingenious contrivances, any person's handwriting can be exactly copied, at any distance, through the medium of the telegraphic wires. At one end of the line is the transmitting apparatus, and at the other the recipient apparatus includes a sheet of paper which has a dark tint imparted to it by a series of closely-ruled lines. The words of the message are written at the one station, and at the other station the same words are reproduced, at the rate of 500 letters per minute, on the sheet of dark paper, in a pale tint.

The American *Bell* telegraph, used at some of the large hotels in New York and other United States cities, and in the magnificent Atlantic steamers of Collins's line, is a registering apparatus, in so far as it records the name of the bell which was last rung. It has no connection with electrical arrangements. There is an upright case or box, two or three feet square, through the top of which descend bell wires from all the rooms placed in connection with the apparatus. Within the case is a bell, the hammer of which is moved by pulling any of the wires; but this is not all; for at the instant the bell is struck, a small white semicircular plate in the front of the machine is turned

half round, and reveals the number of the room whence the bell was rung, or the message to be delivered. There are eighty or a hundred of these plates, and may be any number more or less; each has either a number or a word or two written so as to be concealed and revealed by it alternately; the numbers are those of the rooms, while the words are such as "Waiter," "Boots," "Hot Water," and others indicating the daily wants of hotel and cabin visitors. One bell serves for all; and when this bell is heard, one of the little plates will be found to be moved so as to reveal the message. There is internal mechanism to connect each wire with its appropriate number plate, and also with the bell. A small handle at the bottom of the case re-adjusts all the plates. It is obvious that, by numbering and inscribing the plates accordingly, such a bell apparatus might be adapted to mercantile and warehousing establishments.

There is something ingenious in the mode which Mr. Blaycock, of Carlisle, has recently proposed for regulating the supply of gas to lamps, according to the length of night at different periods of the year. The apparatus is intended for use with illuminated clock dials. On the longest day, a gas-valve is so adjusted as to supply gas for a very short night—the shortest in the year; every succeeding night the supply becomes increased in quantity to about the extent that the night lengthens, until, at midwinter, the supply is most considerable. The instrument then requires re-adjustment, which enables it gradually to shorten its supply of gas during half a year, until the minimum is again reached. The light *puts itself out* at sun-rise, or some desired period near it, by the exhaustion of its supply of gas; and the quantity of this supply is determined by the extent to which the gas-cock is opened, this extent being itself governed by the works of the clock.

It would take us beyond the scope of the present subject to dilate upon the contrivances for teaching the blind to read, cipher, &c.; but there has been sent to the Great Exhibition a machine by M. Foucault, himself a blind man, which has a peculiar registering power and is exceedingly ingenious. A blind man is enabled to write his thoughts by this contrivance, even though he may never have learned to form a letter: he *prints* instead of writes. This machine exhibits thirty or forty vertical brass rods, ranged in two rows. At the top of each rod is engraved, in bold relief, a letter of the alphabet, or a grammatical stop or sign; and at the bottom is a corresponding letter, stop, or sign, formed of ordinary type. A piece of blackened paper, with white paper beneath it, is placed underneath the rods, and on the pressure of any rod a black type-printed mark appears on the white paper. But to make the arrangement available for successive lines of writing, contrivances of a most ingenious character are introduced. Although we have spoken of the rods as being vertical, the lower ends converge so that all the types make their impression at one point; and if the paper were not moveable, the impressions would be superimposed on that point; but the paper has a slow lateral movement for successive letters and words in one line, and a vertical movement for successive lines in the page. Suppose the poor blind student wish to write or imprint the word "France," he presses with his fingers on the six corresponding rods, which bring the six types in proper order on the paper; they all converge to the same point, but as the paper has a gentle side movement after each contact, the blackened type impressions assume the proper order for forming the word.

One of the oddest calculating or registering machines (if we may so designate it) is, perhaps, Mr. Clark's *Eureka*, which was the subject of much newspaper gossip half a dozen years ago. It multiplied Latin words into hex-

ameters, instead of single numerals into larger quantities. Mr. Clark's machine, so far as it could produce hexameters at all, produced them all after one uniform type. Each of his lines consisted of six words, one to each foot; in each line the first word was an adjective of three syllables, the second a noun of two syllables, the fourth a verb of three syllables, and so on. All the six words agreed in gender, number, person, and case, so as to form collectively a sentence; and all the lines were analogous in structure. It seems, so far as the construction of the machine has been described, as if these words were treated as so many dice or dominoes, or rather as so many tickets in a lottery. Put in, we will say, half a dozen adjectives of similar grammatical form, half a dozen nouns, half a dozen verbs, and so forth; then turn the handle, or rattle the box, or go through the necessary hocus-pocus; lastly, draw out an adjective, then a substantive, then one of each of the other four kinds of words; and these six, placed in line in certain order, would form a correct hexameter. We do not present this as the actual process, but merely as a means of showing how, by permutations among a definite number of words, many times that number of hexameter lines may be produced. The common rule of permutation shows us that, even with only six words of each kind, nearly two hundred changes may be produced without departing from the hexameter form; and if the numbers are greater, the changes may be made almost inexhaustible. It is in this sense that the machine may be said to manufacture verses in any desired quantity. Mr. Clark, describing his machine in the pages of the *Athenæum*, said that it is "neither more nor less than a practical illustration of the law of evolution. . . . . . . . The machine contains letters in alphabetical arrangement; out of these, through the medium of numbers, rendered tangible by being expressed by indentures on wheel work, the instrument selects such as are requisite to form the verse conceived; the *components* of words united to form hexameters being alone previously calculated, the harmonious combination of which will be found to be practically interminable."

The metal-working processes, by which all the machines noticed in this sheet have been produced, do not need special description. The fashioning of wheels, pinions, levers, and other delicate bits of mechanism, comes within the ordinary labours of the machinist and the clock-maker. It is to the mental power exhibited in the inventions, and to the imitation of mental power displayed in the action of the machines themselves, that the reader's attention is here directed

# INDIA RUBBER AND GUTTA PERCHA.

We are about to bespeak the reader's attention to two very remarkable substances, which have wrought no inconsiderable revolution in industrial arrangements within the last few years. They are brethren in origin, and brethren in many of their qualities; yet they differ sufficiently to leave an independent range of action for each. Chemists tell us that the constituents are almost identical, comprising about seven-eighths carbon to one-eighth hydrogen; but that gutta percha contains also a little oxygen, which seems to be wanting in india rubber. Both are elastic, both are tough; but if we say that india rubber is more elastic than tough, and gutta percha more tough than elastic, we shall probably place them on their proper relative footing.

## INDIA RUBBER.

It is curious to observe the incongruity often existing between a substance or an agent and the name by which it is known. This name was, in many cases, given to it when its properties were but little developed, and becomes ill-fitted as a designation at a later period of its history. "Electricity," for example, is a word nearly equivalent to "amber-science," and was given to the wonderful agent to which it relates because the electric properties of amber happened to be those which first drew attention: if philosophers had now to re-designate the science, they would certainly dethrone amber from its high position. Taking a humbler example, we may deem the name of "India rubber" to be fairly open to the same scrutiny; this substance was first known to us as a rubber for obliterating pencil marks, and it was brought to Europe from those parts of South America, the natives of which were (and often still are) vaguely called Indian. If a name were at the present day given to the substance, which should characterise its more important qualities, it would not be "rubber," either Indian or otherwise, but something expressive of elasticity. What may be the meaning of the native name, *caoutchouc*, we do not know; but as, by taking a little liberty with the vowels, this may be made a "word of two syllables," it has an advantage over the longer and more clumsy designation "India rubber," which, in such a business-like age as the present, might be worth attending to.

### The India-Rubber Tree and its Sap.

The extensive use of india rubber is entirely of modern growth; dating back about a quarter of a century. But the substance itself has been long

known, and employed in small quantities in most European countries. In this respect it is unlike its young companion gutta percha, which has not yet seen its tenth year. One property or quality after another has been found to pertain to this substance; and each of these successively-discovered properties has been made the basis of a new class of manufacturing operations.

In a work by Torquedama, a Spanish writer, who described the Indians of South America about a century and a half ago, we are told, that there was a tree which the Indians called *usquahuitl*, and which yielded a gummy liquid held in high estimation by them. "To obtain it," he says, "they wound the tree with an axe or a cutlass; and from these wounds the liquor drops. The natives collect it in round vessels of different sizes, called, in their language, *xicalli*, but by us *calabashes*. In these they allow it to settle in round balls, of the size most convenient for the purposes to which they are about to apply them. When quite set, they boil them in water, in which state the gum is called *ulli*." But the natives appear to have been in nowise particular as to the mode of collecting; their naked bodies formed a convenient core or mould on which to collect the material; for they smeared themselves with the gum, and removed the incrustation when dry. The natives, we are informed by this writer, made breast-plates of thick layers of the gum; they extracted an oil which was much used in medicine; they made elastic balls which were used in certain games: and their practical jokers or merry andrews shod themselves with pieces of the gum, the elasticity of which gave rise to ludicrous contortions and boundings. The Spaniards speedily learned to appreciate the waterproofing qualities of this singular substance, by applying it as a liquid to their cloaks.

It was either by this work of M. Torquedama, or by some other description written about the same time, that india rubber first became known in Europe. The true nature of the substance and the tree which yields it was, however, first ascertained by the French Academicians who visited South America in 1735, and was described to the Academy by Condamine in the following year Europeans had long before been struck with the odd appearance of the fan tastic bottles, birds, and other forms into which the gum had been fashioned by the collectors; but they were now able to know something concerning the tree whence it exudes, and the manner of obtaining it. Besides the true caoutchouc tree, there are many others which yield a gum nearly identical with india rubber; among these are the *Jatropha elastica*, the *Ficus indica*, the *Artocarpus integrifolia*, and the *Urceola elastica*.

The method of obtaining india rubber for the ordinary purposes of commerce, does not differ much from that described by the old Spanish writer. The substance as it comes to us is mostly dark in colour, but this hue arises from the mode in which it is prepared for market; for the juice itself is milky in consistence, and nearly white in colour. The trees are usually pierced in the rainy season, at which time the juice is most abundant. If the juice be received in bottles, and be well corked immediately, it may be preserved in a liquid or semi-liquid state for a considerable time; but the natives have no object in so doing. They go to the forest early in the morning, tap the trunk with a small pickaxe, and fix a cup of soft clay beneath the wound; in the evening about a quarter of a pint of the milky juice is found in the cup. This is the true or American india rubber; the Asiatic species will yield fifty to sixty pounds per tree in one season, but this is of inferior quality. The juice, when thus collected by the natives, is spread in a thin layer on clay forms, fashioned in any way that the rude taste of the collectors dictates; this

layer is dried by the heat of a smoky fire; another layer is applied; another drying follows—and so on, until a coating of considerable thickness is obtained. This coating may be punctured or stamped, or pressed with any device, at pleasure; and thus are sometimes produced birds the genus or species of which it would baffle the skill of an Audubon or a Wilson to determine. When all is dry, the clay mould or core is crushed to fragments, the fragments removed, and the india rubber shell liberated. So smoky is the fire at which the juice is dried, that a bottle-form piece of india rubber may be characterised as an alternation of layers of gum and soot.

Numerous are the purposes to which this singular substance is applied in the countries of its production. The Indians fashion it into rudely-shaped boots, for the rainy season. The inhabitants of Quito apply it as a coating to cloth, to make rainproof tarpaulins or coverings. It is formed into flambeaux, which yield a beautiful light, accompanied, however, by an odour which is not usually grateful to European nostrils; it is said that a flambeau, two feet long by an inch and a half in diameter, will burn twelve hours.

But it is in Europe that the qualities of india rubber have chiefly become ascertained. It is now recognised as the most pliable and elastic of known substances; while it is so tenacious that it cannot be broken without considerable force. All that was then required was, to find out some solvent which would bring it to the liquid form, so as to enable it to be applied as a varnish, a cement, or a protective coating; this our chemists have succeeded in doing, and the result is a very wide extension to the useful applications of the gum.

## India Rubber Processes: Elasticity.

The india rubber, or caoutchouc, now imported to the enormous extent of six or seven hundred thousand pounds annually, reaches this country in masses of varied shape, but mostly of a dark colour. In its imported state it is used for very few purposes; considerable modifications being necessary for its adaptation to practical service. It requires to be transformed into cakes, or sheets, or tissues, or tubes, or solutions, preparatory to its ultimate use; and this transformation requires operations of a somewhat peculiar kind, owing to the necessity of rendering the whole mass homogeneous in substance.

The bottles, and masses, and fragments, as imported, have much inequality in texture, and are, moreover, contaminated with much dirt and refuse. To separate these the india rubber is first cut into very small fragments, and then steeped in warm water, by which the dirt is precipitated. The fragments are dried, and are then thrown into a kind of kneading machine, where immense pressure is employed to bring them to one homogeneous mass. There is in this kneading process evidence afforded of a very remarkable difference between gutta percha and india rubber; the former (as will be explained in a later page) requires to be heated to a soft state before being placed in the kneading mill; but the india rubber, though put in cold, becomes so hot by the agitation that it could not be safely touched by the hand; it is necessary to supply the machine with cold water, which is made nearly to boil by the caloric driven out of the elastic mass. So thoroughly is the mass pressed, rolled, pricked, cut, and kneaded, by the severe turmoil which it undergoes, that all dirt, air, water, and steam are expelled, and it presents the appearance of a dark-coloured, uniform, smooth mass. It is put into cast-iron moulds of great strength, and brought, by hydraulic or screw pressure, to the form

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of blocks, slabs, or cylinders, according to the purpose to which it is to be applied.

These blocks, or other masses, occupy the transition stage between the preparatory and the finishing processes; the india rubber is brought into a usable state, but not into useful form. It is as a *sheet* and as a *thread* that the material meets its most extensive application; and both of these are made by cutting from the blocks and slabs. A block is cut into sheets by an ingenious machine, in which a sharp knife-edge has a rapid vibratory motion in a horizontal plane, so adjusted as to cut a thin film from a block of india rubber supplied to it by a steady motion. The knife requires to be kept cool by a flow of water, or it would adhere to the india rubber. In this way thin sheets may be cut, or thicker sheets from which stationers' india rubber may be obtained, or sheets of any thickness, great or small, according to the purposes required.

The separation of the material into shreds or narrow strips is a very pretty operation, exhibiting much nicety of manipulation. A continuous strip may be cut from a bottle or any other curved mass of the india rubber. The bottom of the bottle is cut off, and is pressed into a round and tolerably flat form. The cake thus fashioned is fixed to the end of a horizontal shaft, or lathe-axis, and is made to revolve with great rapidity; and while so rotating, a circular knife, rotating at a high speed, cuts through the substance, and advances steadily towards the centre of the disc; thereby separating the disc or cake into one continuous spiral thread. This thread can be easily drawn out straightly, and can even be separated into two or more finer threads, by drawing it through a hole where one or more sharp-cutting edges encounter it. If a bottle or any other hollow piece of india rubber can be drawn over a cylinder of uniform diameter, it may be cut into a continuous thread by a modification of the same machine; the cylinder being made to revolve, a steel cutter is placed against it, and as the cylinder has a slow longitudinal motion given to it, the gum is cut spirally from end to end—just on the same principle as a worm or thread is cut on a bit of iron by the screw-cutting machine. Machines of this kind were invented in France more than twenty years ago; but the machines used in our own country are of English invention and of later date.

If we glance among the stores of the india-rubber manufacturers and retailers at the present day, we find that braids and cords, webs and bands, form no inconsiderable portion of the wares exposed for sale. These, in most cases, require that the india rubber should be first made into blocks or cakes, next cut into sheets, and then separated into threads or cords or narrow strips. Supposing these preliminary cuttings to be effected, the making of braids and webs is exceedingly curious, for it involves a combination of the india rubber with other materials. Let us briefly trace the processes. In the first place the narrow cords are stretched by a kind of wheel, and kept extended till nearly deprived of their elasticity, and till they form a thread of the desired thickness. The thread is then put into a *braiding-machine*, which is a complicated and very ingenious apparatus, whereby a sheathing of cotton, silk, flax, or worsted, is wound round the india-rubber thread. In such a machine several threads are twisted round each other, from three to nearly thirty in number; each thread has its own bobbin, and all the bobbins revolve round a common centre, giving out their threads in the proportions and order required. The visitors to the Great Exhibition have had opportunities of seeing some such machine at work. Generally speaking, the braiding-machine

is employed in making stay-laces, braid, upholsterers' cord, &c.; but it is also applicable in making the numerous elastic cords and webs which owe their elasticity to india rubber. When an envelope of cotton, silk, flax, or worsted has been given to the thread of india rubber by the braiding-machine, the threads are laid as warp in a loom, and woven into the required kind of web, whatever it may be. Then comes a curious development of the properties of the material; in the preliminary stretching, the india rubber was made somewhat stiff and unyielding; but by now exposing it to the action of a hot smoothing-iron upon a table, the elasticity is restored, the riband or web contracts in length, and the sheathing or envelope corrugates or wrinkles up on the surface. The web thus produced is very soft and elastic. The warp threads may be alternated with others of non-elastic character; and the weft-threads may be either elastic or non-elastic, so that any desired degree of elasticity may be obtained.

Why a piece of india rubber, when it has been somewhat modified by heat and chemical action, should be deemed *vulcanized*, it is for the inventor to say. Vulcan *may* have been the god of fire, and may have "forg'd the thunderbolts of Jove;" but he must have done something much more important than dress up a bit of india rubber to deserve his mythological fame. However, let us take the name simply as the expression of a fact, that fire or heat has been brought to bear upon this substance as a means of affecting its qualities. The method was invented by Mr. Hancock seven or eight years ago, and it has been the means of giving a wide extension to the use of india rubber.

This vulcanized india rubber is in fact a compound of sulphur with the vegetable gum. When a sheet of india rubber is immersed in liquid sulphur, a marked change takes place in its qualities; the sulphur acts upon the gum and combines with it; and indeed the two may almost be said to form a new substance. The methods by which the combination is brought about are varied, but the effect is in all cases very remarkable. The strength of the india rubber is increased to an extraordinary degree. The elasticity is rendered more permanent, analogous in some respects to that of gutta percha. The new substance will absorb essential oils without injury, whereas such oils would dissolve india rubber. It retains its properties at a temperature so low that india rubber would be too much hardened for use; and at a temperature so high that india rubber would be destroyed. Later experimenters have found that antimony, and many other substances, may similarly be combined with india rubber; and it is reasonable to expect that many useful novelties are in store for us in this "vulcanized" direction.

One very remarkable manifestation of the elastic properties of this substance is to be met with in Mr. Shaw's novel india-rubber air-gun. This gun requires no gunpowder whatever, and is so far a very economical production; but its wonders do not cease here; for it has no air-pump, no reservoir, no valves. We might marvel how it would be possible to discharge a missile by such means, were it not that the inventor shows the mode in which he brings india rubber to his aid. The air which expels the ball is, it seems, powerfully compressed at the moment of discharge by a piston acting within a cylinder, and moved with great force and rapidity by the sudden contraction of a spring. This spring is composed of a number of vulcanized india-rubber rings, and is capable of being distended or stretched by hand in a convenient way. The ball is propelled with a force equal to that exerted in an ordinary air-gun; and with much facility and precision. It certainly seems strange that such an instrument should possess sufficient projectile power to flatten a bullet

propelled from it; but Mr. Shaw has displayed at the Great Exhibition bullets so flattened, as companions to the gun itself.

It is not easy to say whether the most numerous and important applications of this singular substance depend on its use in the form of thread, or that of a liquid solution; each has its advantages, which keep it distinct from the other. When once it was discovered that india rubber may be dissolved in petroleum, in naphtha, or in oil of turpentine, it was speedily seen that a new and extensive sphere of utility was given to it. And another advantage springs from this; that any fragments or odds and ends will suffice as well as large and well-prepared pieces. The coarsest pieces as imported, the waste from the kneading operations, and the parings and cuttings from other manufacturing operations, are placed in a close iron vessel, to which the liquid solvent is added. A brisk agitation is kept up, and the heat thereby generated in the elastic gum warms the liquid and increases its solvent power, until at length the whole of the gum is dissolved. This operation is conducted on a somewhat extensive scale; for the iron vessel is large enough to contain more than half a ton of india rubber, which requires three days of constant agitation for complete solution. The liquid thus produced has a consistency which fits it to be used as a varnish, or as a waterproofing medium, or as a cement, or for many other purposes which the sagacity and self-interest of manufacturers have enabled them to discover.

## India Rubber Processes: Waterproofing.

Besides the cutting up of solid india rubber into the varied forms of shoes and other articles; besides the spinning, and braiding, and weaving threads of these substances into cords and elastic webs; there is now an enormous consumption of this material in imparting waterproof and airproof qualities to woven fabrics, which would otherwise be wanting in such virtues.

The world-renowned "Macintosh" capes and cloaks, and other rain-resisting garments, do indeed deserve most if not all the encomiums passed upon them. It is true that they check the exit of perspiration, and have one or two other inconveniences, but they are brave companions nevertheless. Mr. Baillie Fraser, in the narrative of his rapid and somewhat perilous winter journey from Constantinople to Persia, a few years ago, says:—"But as my furs alone would have made a poor defence against rain or falling snow, I had provided myself with a good Macintosh india rubber cloak, which now did worthy service." Many a traveller has been able to make a similar acknowledgment. Whether the plain cotton "Macintosh" garments are destined to be superseded by the "Siphonia," or other novelties of later introduction, the wearers must determine.

The manufacture of the Macintosh cloth is a singular one. The material is merely two layers of cotton cemented with liquid india rubber; but the junction is so well effected, that the three become to all intents and purposes one. The stout and well-woven cotton cloth is coiled upon a horizontal beam, like the yarn beam of a loom; and from this it is stretched out in a tight state and a nearly horizontal position. A layer of liquid or rather paste-like solution is applied with a spatula, to a considerable thickness, and the cloth is drawn under a knife edge, which scrapes the solution and diffuses it equally over every part of the cloth, which may be thirty or forty yards long. The cloth is then extended out on a horizontal framework to dry; and when

dried, a second coating is applied in a similar way; and a third and fourth may be similarly applied if necessary. Two pieces, thus coated, are next placed face to face, with great care, to prevent creasing or distortion; and, being passed between two smooth wooden rollers, they are so thoroughly pressed as to be made to unite durably and permanently. Cloth, thus cemented and doubled and dried, may be cut and made into garments which will bear many a rough trial and many a deluging before rain or water can penetrate.

India-rubber occupies a very notable position in connection with the numerous "life-preserving" projects. Its power of resisting the action of water lies at the root of this application: we have garments, and floats, and buoys, and boats, presented to our notice in great numbers. One inventor has claimed public attention to a safety-boat, formed of a kind of canvas bag saturated with liquid india rubber. Another has displayed his ingenuity in a boat, of which the frame-work is cork, and the covering india-rubber canvas. A boat was constructed in France, a few years ago, in which many curious arrangements were involved; it was formed of skeleton frame-work, capable of being hinged or unhinged at pleasure, and over each frame a covering of saturated canvas was spread. "As an example of strength, lightness, and portability," we are told, "a large boat in this form was tried in France, in 1841. It was more than a hundred feet long; and although formed with canvas sides, it was loaded with nearly one hundred tons of wood and wine, which it safely conveyed from Auxerre to Paris, down a shallow and much interrupted stream. It was then taken to pieces in three or four minutes, and all the materials packed in two carts, which took it to Auxerre for another cargo."

The buoys and garments of india rubber are, perhaps, still more varied than the safety-boats. Whether the "safety-hat" still survives to render service to those who may be lucky enough to be covered with it, we do not know; but according to the theory of its inventor it was intended to act as follows:—the hat and its lining were both to be rendered impervious to water by a solution of india rubber; and air being blown in between the two, it was considered that such a hat, if allowed to swim on the water, would bear the weight of a man clinging to it. In a "life-cloak," or "life-cape," introduced by Messrs. Macintosh, the cape is made of a double thickness of india-rubber cloth, with a provision for forcing air into the interstice between the layers, and thus rendering it buoyant. Among other novelties, "yachting jackets" are displayed, which, while they present the requisite external neatness of appearance for amateur seamen, are yet said to possess buoyancy enough to float the wearer—a property due, no doubt, to a little application of the magic india rubber. Nay, ladies' "paletots" are exhibited with the same ascribed qualities. Beds, mattrasses, hammocks, pillows—all made of india-rubber cloth—have been proposed and introduced as life-buoys; and belts and gloves may be added to the list.

But it is striking to observe how little these matters are attended to in practice. Our inventors patent, our exhibitors display, and our journalists describe, numberless ingenious contrivances having the life-buoyant or rather body-buoyant property in view; but how few persons adopt them! Sea-going people can swim as little now as they could half a century ago (and this little is much less than landsmen usually suppose); but yet we very seldom hear of life being saved by the hats, capes, cloaks, belts, mattrasses, &c., which the india-rubber inventors have provided—not because the india

rubber fails in its duty, but because foresight is seldom shown by those for whom the inventions were intended.

It was a happy thought of the benevolent physician who first suggested the *water-bed.* Dr. Arnott has brought forward many useful inventions applicable for the most part towards the preservation of health, or the alleviation of suffering; he patents none, but leaves society to reap whatever advantages may accrue therefrom; and he has had twenty years of that pleasure which results from doing good for the sake of the good done. Dr. Arnott has published an interesting account how, about twenty years ago, he was led to the invention of the hydrostatic or water-bed for invalids. A lady, severely prostrated by illness, and bed-ridden for a long period, suffered much from the pressure even of the softest bed that could be supplied to her—a pressure which can be appreciated only by those who are helplessly confined to one position in bed. "Under these circumstances," says the ingenious physician, "the idea of the hydrostatic bed occurred to me. Even the pressure of an air pillow had killed her flesh, and it was evident that persons in such a condition could not be saved, unless they could be supported without sensible inequality of pressure. I then reflected, that the support of water to a floating body is so uniformly diffused, that every thousandth of an inch of the inferior surface, has, as it were, its own separate liquid pillar, and no one part bears the load of its neighbour; that a person resting in a bath is nearly thus supported; that this patient might be laid upon the surface of a bath, over which a large sheet of the waterproof india-rubber cloth had been previously thrown, she being rendered sufficiently buoyant by a soft mattrass placed beneath her; thus would she repose on the face of the water, like a swan on its plumage, without sensible pressure anywhere, and almost as if the weight of her body were annihilated." A bed was made on the principle suggested; the invalid gained instant relief, and ultimately recovered; and "Arnott's hydrostatic bed" became known in hospitals and in the chambers of the sick.

It is not our province to dwell farther on this matter here; it only concerns our present subject so far as it illustrates one among the many uses of india rubber; but it is valuable, as showing what good may be drawn out of almost any agency, when the heart as well as the head is engaged upon it.

## India Rubber at the Great Exhibition.

The Great Industrial Exhibition has shown, as it ought to have done, how varied are now the applications of this material. We have there seen, in Mr. Hodges' contributions, a peculiar application of india rubber to projectiles, and a somewhat similar application to mechanical purchase or tackle. This tackle, highly elastic from the nature of the substance employed, is substituted for, or used in combination with, the rigid kind ordinarily employed; and it is so applied, that one man may bring an extraordinary amount of power to bear on the body to be lifted or moved; there is a kind of accumulation of power going on in the process, and hence the apparatus has received from its inventor the name of the *cumulator*. Another exhibitor has contributed india-rubber saddles and collars; a third, an india-rubber waterproof umbrella tent; a fourth has a goodly collection of webs, braces, garters,

wristlets, glove tops, braided webs, bead-threading, and such like small wares. Mr. Mathews offers for our inspection an india-rubber portable boat, useful for lake fishing and duck shooting; and a portable bath of similar material. But his most singular contribution is a waterproof cloak-boat, "which, when inflated, renders it capable of being used as a boat, and enables travellers to cross rivers or streams where no other means are at hand:" the wearer takes off his cloak, draws out a tiny pair of bellows from a pocket in it, fills a vacant space within the double cloth with air, floats the cloak on the water, takes his seat in the centre, and forthwith paddles along with a small pair of paddles taken from another pocket—a very *multum in parvo*, if it will do all that the inventor ascribes to it. Messrs. Bunn and Lockington, who are importers of this material, have very appropriately afforded the means of comparing different specimens of this produce; they show us both the Brazilian and the Asiatic varieties, classified according to their value and application; and they also exhibit samples illustrative of the various stages of the manufactured articles. Mr. Hancock has furnished the means of comparing the plain india rubber with the "vulcanized" material, on which his ingenuity has been engaged.

But it is the firm of Messrs. Macintosh by whom this branch of industry has been most fully illustrated. Here we find, in the first place, specimens of india rubber in the imported state, exhibiting various degrees of quality. Next we find it in the partially manufactured state, in many stages of progress, and in both the "vulcanized" and the non-vulcanized condition. Thirdly, we have a group illustrative of the water-resisting quality of the material: such as inflated boats, life-belts, cushions, pillows, beds, sponging baths, sheets for covering waggons and ricks, waterproof garments, sporting and travelling appendages of various kinds, water and airproof fabrics, invalid or Arnott beds, and many other articles of analogous character. Next we find illustrations of the elastic qualities of the material, in such articles as the various elastic webs and woven fabrics for dress and for furniture, springs for doors, bands and bandages, buffer and bearing-springs for carriages, tires for noiseless wheels, sewer and sink valves, torsion spring-roller blinds, washers for flange and socket joints, &c. Another group comprises such articles as require both the impermeable and the elastic qualities of the material; among these are decanter and bottle stoppers, boots and shoes, surgical and veterinary implements, chemical apparatus, calico-printing apparatus, and ship-sheets for occasional use at sea. Added to all the above are other manufactured articles of most miscellaneous character: including sockets and pistons and packing for machinery, elastic maps, prints, and embossings, printed webbing, thread for ladies, ornamental work, and numerous others.

Nor have our continental and transatlantic friends failed to do their best in illustration of this department of industry. From Guiana, one of the homes of the india-rubber tree, we have specimens of the raw material. From France we have india-rubber braces and twists, stockings and knee-caps, belts, tissues, bandages, and surgical apparatus. Holland bids us admire her vulcanized india-rubber boots and shoes. From Russia we have india-rubber clogs. Switzerland has sent knit stockings for invalids. The States of the Zollverein have their india-rubber braces for our notice. But it is from across the broad Atlantic that the largest and most interesting collection in this branch of industry has been sent; it is indeed so marked as to form a conspicuous portion of the somewhat thinly-spread consignment from the United States to the Great Exhibition. One would think that Brother Jonathan

must be in constant peril of drowning, from the multiplicity of floating life preservers here contributed. Every quality which india-rubber can possess seems to have been brought into requisition: impermeability, elasticity, toughness, smoothness—all are made to bear a part. We have the "Hayward Rubber Company," and the "Goodyear Rubber Company," both contributing their boots and shoes, cloaks and capes, hats and caps, leggings and gaiters, belts and gloves, and other water-resisting garments. The production of very thin sheets of india-rubber, and the printing of some kind of device on one surface, are carried on with much effect. There are, for instance, india-rubber floor-cloths of considerable size; and india-rubber prints and maps which receive a printed impression with a delicacy nearly equal to that of paper. There is an india-rubber globe, made of tissue so thin that it can be readily inflated by the breath through a small stop-cock. There are also india-rubber veneers, thin and flexible, ready to be applied to any suitable surface. In the vulcanized form, the American specimens embrace a range which will not yield in variety to that of the mother country; for besides such articles as balls, whips, mail-bags, swimming apparatus, cushions, saddles, bags, gas-bags, &c., we have no less a curiosity than a "vulcanized india-rubber flute."

Dairy-husbandry has recently availed itself of the services of india rubber, in a somewhat singular way, in the milking of cows. The teats of the cow are each covered with a case or sheath of india-rubber, having a small tube and stop-cock at the bottom. It would appear that some kind of pressure is exerted by the sheath; for the milk is said to flow without the usual action of the hand. The saving of time is the object apparently held in view in this odd contrivance; for a saving there is asserted to be.

One of the characteristics of our age is a yearning to imitate the qualities of a substance by some substance of cheaper price. India rubber has not escaped this mode of attack. Certain experimenters tell us, that "if well-prepared boiled linseed oil be applied, by means of a brush, to any smooth surface, and dried in the sun or smoke, and the process repeated until some thickness be attained, it will afford a substance of considerable fineness, semi-transparent, wonderfully elastic, and resembling india rubber in most of its sensible qualities." Hence is produced *artificial caoutchouc;* but the formidable period of six months is said to be necessary for the production.

## GUTTA PERCHA.

Another remarkable vegetable product, another elastic gum, now awaits our notice.

### Gutta Percha in the Forest.

It was in the year 1842—not yet ten years ago—that Dr. Montgomerie, an Assistant-Surgeon to the Residency at Singapore, accidentally lighted upon a knowledge of this remarkable gum. He was one day watching a *parang*, or native wood-cutter, at his labour; and was struck with the remarkable appearance of the hatchet or chopper employed by him. The handle seemed to be formed of some material very different from those usually employed. "I questioned the workman," says Dr. Montgomerie, "in whose possession I saw it, and

heard that the material of which it was made could be moulded into any form by dipping it into boiling water till it was heated through, when it became plastic as clay, regaining when cold its original hardness and rigidity." An intelligent physician was not likely to lose sight of such a remarkable substance; the seed was pretty sure to take root in the mind of one conversant with the materials of manufacture employed in Europe, and with the advantages which would accrue from any increase in the number of such materials. He speedily ascertained that gutta percha, like caoutchouc, exudes from between the bark and the wood of certain forest-trees. He procured specimens in various stages of preparation, and sent them to the Society of Arts in London. Seldom has the Society's gold medal been more fittingly awarded, than for the valuable knowledge thus communicated to the manufacturers of our country.

It is observable, however, that this substance may be said to have had two European discoverers, independent of each other; for the tree, and the gum which exudes from it, were discovered or observed by Mr. Thomas Lobb. This gentleman visited the islands of the Indian seas in 1842-3 on a botanical mission, as agent to Messrs. Veitch, the scientific and energetic florists of Exeter; and it was during his rambles that he became acquainted with the gutta-percha tree. It is not, however, very remarkable that such a substance should have two independent discoverers—the histories of the planet Neptune, of photography, and of electrography, have taught us striking lessons on this point.

The small sample of specimens which Dr. Montgomerie sent to England has a kind of historical interest attached to it, in being the humble beginning whence an important branch of industry has arisen. Several ingenious persons applied practical tests to the newly-imported substance; and among them Mr. Whishaw and Mr. Hancock speedily showed how easily gutta percha might be fashioned into useful forms. Mr. Whishaw made a piece of pipe and a lathe band, which he exhibited before the Society of Arts; he also produced impressions from medals; but the most striking testimony to the singular properties of this substance was afforded in the following way: he softened a lump of gutta percha by hot water, pressed it out to a thin sheet, covered a soda-water bottle with it, hardened the surface by dipping in cold water, softened and removed the coating, and rolled up the gum again into a form similar to that which it first presented. The piece of pipe and the lathe-band displayed by Mr. Whishaw at the Great Exhibition are, we believe, the same which were produced on the occasion above alluded to, and are perhaps the first letters of this industrial alphabet. In the meantime Mr. Hancock, studying closely the properties of the material, contrived those methods and secured those patents which have been the basis of much of the subsequent operations.

In proportion as the value of this substance has become known, so has a desire extended to ascertain the range of its growth in the East. It is now known that the gutta-percha tree abounds in that extreme south-eastern point of Asia which obtains the name of the Malay Peninsula; in the neighbouring island of Singapore; in the important Bornean island which Rajah Brooke has been the means of making so familiarly known to us; and in various islands which constitute the Eastern Archipelago. There seems very little cause to apprehend any failure in quantity; for even if the present supply from the neighbourhood of Singapore should be exhausted, the capabilities of more distant islands are quite beyond present calculation.

An interesting sketch was given in the *Daily News*, a few months ago, of the spread of the gutta-percha trade, when once it became known that a market had sprung up for that material. The jungles of the Johore Archipelago, some distance from Singapore, were the scene of the earliest gatherings; and they were soon ransacked in every direction by parties of Malays and Chinese; while the indigenous population also gave themselves up to the search with zeal and avidity. The Tamungong, or chief, declared the precious gum to be a government monopoly—a stroke of policy at which we need not marvel greatly; he appropriated the greater part of the profits, and still left the Malays enough to stimulate them to pursue the quest; and these Malays, in their turn, obtained an enormous profit from the labours of the Aborigines. In short, the gutta-percha fever in the east paralleled the railway fever in the west, but came a little after it in point of time. Besides all the other sources of profit, the Tamungong employed whole tribes of hereditary serfs in the search for gutta percha. The gum hunters went from island to island in quest of the precious commodity; but here they met with new claimants; the petty sultans each imitated the Tamungong, and declared gutta percha to be a regal monopoly. The commercial value of the gum being determined by the best of all tests at Singapore, the desire to gather it spread like wildfire: northward to Pinang, southward to Java and Sumatra, eastward to Borneo—thus the fever marched. The gutta-percha tree was found in many parts of Borneo: such as at Bruné, Sarawak, and Pontianak on the west coast, and at Keli and Passir on the east coast. At the present time there is very little doubt that the forests of the Indian Archipelago are being penetrated in every direction, in search of these valuable trees: it will be one of the means of clearing the land for future dwellers in those regions.

It appears that *percha* (of which the pronunciation is *pertsha*, not *perka* or *persha*) is the Malayan name for the tree which produces the gum; while *gutta* is a general name for any gum which exudes from a tree. The tree belongs, of course, to the group in which botanists place *sapotaceous* or gum-exuding genera. The wood of the tree, being soft and spongy, is not applied to many useful purposes. The fruit yields a thick oil, which is used by the natives with their food; and either from this or from some other parts of the tree an ardent spirit is capable of being distilled. But it is the sap which forms the most valuable product of the tree. It circulates in small vessels which run up between the bark and the wood.

Thrifty methods are teachable to rude islanders as to more civilised men, when the advantages have been once made apparent. The natives around Singapore, when they first found a market for the solidified gum, proceeded ruthlessly to work; they killed the bird which laid the golden eggs, by cutting down the trees in order to obtain the gum. But they have now been taught better; it is shown to them how, by *tapping* or cutting notches in the branches at certain intervals of time, the sap may be made to flow, without endangering the life of the tree. Experiments are now being made to determine whether the gutta-percha tree can be planted so as to maintain a continuous and inexhaustible store of gum or sap: should these attempts succeed, the supply would equal any imaginable demand; and the application of this singular substance might acquire a range of which we little dream at present.

If we follow the history of the gum to the point where commerce takes it up, we are made painfully conscious that rascality finds a hold as in too many other directions. Chicory-coffee and sloe-tea, cabbage-tobacco and sand-sugar, have their parallels in many of the lumps of gutta percha brought to the dealers

at Singapore. Supposing the tree to be tapped instead of felled, the sap flows out gently into any vessels which the natives may choose to employ for this purpose. Before the sap has quite consolidated, it is kneaded into lumps by the hand or by a piece of wood, and these lumps may be of any size or shape that suit the fancy of the forest-artist. If zoologically inclined, he selects the form of a bird or a quadruped, or he may even patronize the "human face divine;" if music charms him, he imitates the forms of such instruments as may be familiar to him; but, generally speaking, the gutta percha presents the form of roundish lumps, eight or twelve or sixteen inches over. This is all very well, so far as shape is concerned. But what if the sample be not as it seem; what if it be fair without and false within? Alas! the purse of the buyer, and the edges of his cutting instruments, have often a sorry tale to tell. The gutta percha is sold at Singapore by weight, according to the apparent quality of each lump; but, when the consignment reaches England, it is not unfrequently found that a large stone or a piece of heavy wood is imbedded in the heart of it, to increase the weight. It would entail a serious loss of time to cut open each lump at the time of purchase; so that at present Oriental honesty is rather an important element in the commercial value of this article. There is, too, a great amount of difference in the quantity of bark, leaves, and dirt, which become accidentally mixed up with the gum.

The crude gum is imported to the extent of about two millions of pounds annually, in the variously-shaped pieces above spoken of; and we may next see what modern ingenuity has effected in devising modes of rendering these pieces either useful or ornamental, or both.

## Gutta Percha in the Factory.

The extensive and highly-interesting establishment of the Gutta-Percha Company, situated near the City Road Basin of the Regent's Canal, is worthy of attention even beyond the general average of such centres of industry, for the peculiar character of the substance operated upon necessitates the employment of new processes, new machines, and new tools. An incessant course of invention has marked the manufacturing history of this material during the brief period of its existence. If the gutta-percha is to be applied to some new useful purpose, tools and processes of novel character have to be employed; if an ornamental application is determined on, methods are adopted for developing any natural beauty which the grain of the substance may present; if an attempt be made to supersede leather, or wood, or papier maché, or metal, by this singular gum, great pains are bestowed on a study of the special qualities to be imitated, and the process of imitation often requires operations and tools differing considerably from those before employed.

A pervading odour is sensible throughout the buildings in which the gutta percha is stored and manufactured. If it were necessary to characterise this odour, we might, perhaps, liken it to a hybrid between tan-bark and old cheese —an odour to which one is not, at first, easily reconciled. But this becomes dissipated after a time.

When we direct our attention from scent to sight, and look around the establishment, we see the very history of the manufacture pictured in the buildings themselves. Every separate block of building speaks of a particular application of the gutta-percha, or some particular mode of preparing it for use. If we see a building somewhat more fresh and modern than its neighbours,

we may infer [illegible] some new or comparatively new process is there carried on; and the area [illegible]hus becoming dotted about with workshops and warerooms, which will not much longer yield each other sufficient elbow space. It is only when we bear in mind the very recent introduction of this remarkable substance, that the extent to which the manufacturing arrangements have grown can be duly appreciated. Store-rooms for the newly-imported gum; steam-engines and boilers for supplying the agency whereby the manufacturing processes are conducted; large buildings filled with the machines and tools for working; workshops in which the finishing processes are conducted; a canal quay for unshipping the raw material, and shipping the finished goods; —all speak of a busy series of operations. It is also proper to remark, that another extensive establishment of a similar character is carried on at West Ham, and that minor manufactories are now scattered over London and other towns.

The Great Exhibition has in this, as in other matters, conveyed to millions of persons a kind and degree of information which would not otherwise be forthcoming. We have there had an opportunity of seeing gutta-percha, not merely in its elegant finished forms, but in all the successive stages of its manufacture. We have seen the rough block or mass, the chips into which this is cut, the shreds into which the chips are torn, the homogeneous mass into which the shreds are kneaded, the sheets into which the mass is rolled, and the finished articles into which the sheets are fashioned; and thus the industrial history of an important substance is spread out intelligibly before us.

The Oriental knavery which leads to the mixing of stones and wood with the masses of gutta-percha we lately adverted to; and a glance at the works of the Company shows us the result. In the store-room the blocks and lumps, of slightly-varying colour and texture, generally present a fair outside, and it is not till the first process has been gone through that the fraud can be detected. This process consists in cutting the block into slices. There is a vertical wheel, on the face of which are fixed three knives or blades; and while this wheel is rotating with a speed of two hundred turns a minute, a block of gutta-percha is supplied to it, and speedily cut into thin slices—much on the same principle as a turnip-cutter performs its work. Woe to the steel edges if a stone be imbedded in the block! all alike, the soft and the hard, are cut through, but not with impunity.

These slices show that the gutta-percha is by no means uniform in different parts, either in colour or texture. To bring about a uniformity is the object of the shredding or tearing process. The slices are thrown into a tank of water, which is heated by steam to such a temperature as to soften the mass; the dirt and heavy impurities fall to the bottom, leaving a pasty mass of gum; and the mass being thrown into another rotating machine, is there so torn and rent and dragged asunder by jagged teeth as to be reduced to fragments. The fragments fall into water, upon the surface of which (owing to the small specific gravity of the material) they float, while any remaining dirt or impurity falls to the bottom. These fragments are next converted into a dough-like substance by another softening with hot water, and the dough undergoes a thorough kneading; it is placed in heated iron cylinders, in which revolving drums so completely turn and squeeze and mix it that all parts become alike, and every particle presents a family likeness to its neighbour.

The kneaded state may be considered the dividing line between the preparatory processes and those which relate to the fashioning of the material.

The soft ductile mass may be formed either into sheets or tubes. In forming sheets the mass is passed between steel rollers, placed at a distance apart corresponding with the thickness of the sheet to be made—whether for the heels of a rough-booted pedestrian, or for the delicate "gutta-percha tissue," now so much employed by surgeons. By the time that the substance has passed through the rollers it has cooled sufficiently to assume a solid firm consistency. By the adjustment of a few knife-edges the sheet may be cut into bands, or strips of any width, before leaving the machine. In making tubes and pipes the soft mass of kneaded gutta-percha is passed through heated iron cylinders, where a singular modification of the wire-drawing process reduces it to the desired form and dimensions.

From the sheets and tubes thus made, numberless articles are produced by cutting and pressing. Machines, somewhat like those used in cutting paper, are employed to cut the gutta percha into pieces. If for shoe-soles, a cutting press produces a dozen or so at one movement; if for string, or thread, narrow parallel strips are cut, which are then rounded or finished by hand; if for producing stamped decorative articles, the sheets are cut into pieces, and each piece is warmed and softened to enable it to take the impress of a mould, or die. But the mode of casing copper wire for electro-telegraphic purposes is, perhaps, one of the most singular applications of the material in the form of sheet. Several wires are laid parallel, a strip of gutta percha is placed beneath them, another strip is placed above them, and the whole are passed between two polished grooved rollers; the pressure binds the gutta percha firmly to the wires, while the edges between the grooves indent the gutta percha so deeply, that it may easily be separated into wires, each one containing its own core of copper.

## Gutta Percha: its Uses for Pipes and Tubes.

The applications of gutta percha in the form of pipe, or tube, are becoming most numerous and varied, and some of them highly interesting. Let us take a hasty glance at the list.

*Water-pipes* have had a few vicissitudes in their history. Those who remember the arrangements for the water-supply of London, in past days, will have been familiar with the wooden pipes, formed of bored trunks of trees, which were wont to be laid down beneath the paving of the streets. These gave way to iron. The smaller pipes have chiefly been made of lead; but zinc in one quarter, brown ware in another, glass in another, have invaded the domain of lead. A new competitor now enters the field. Gutta percha claims to be not merely an efficient material for water pipes, but to possess certain sanitary qualities very important in this sanitary age of ours. It is very strong and tough (say the patentees); it possesses much durability underground; it stoutly resists frost; and it leaves the water as pure as it finds it. Hence it is applied to pump barrels, to ships' pumps, to locomotive feed-pipes, to syphons and mine-pipes, and to fire-engine pipes. But if the testimony of medical men is to be deemed authoritative, the substitution of gutta percha for lead as a material for water pipes is a matter of yet higher import. Dr. Thomas Smith, of Cheltenham, states that "Many serious and alarming disorders, such as mania, epilepsy, sudden death, nervous affection, paralysis, consumption, hydrocephalus, heart disease, &c., owe their origin in some instances, their intractable character in others, to the gradual and

continuous infinitesimal doses of lead, copper, &c., introduced into the system through the channel of our daily drink." It appears that the carbonic acid contained in water has a tendency to combine with the lead of the pipe which contains it, and to generate a compound possessing poisonous qualities. That gutta percha resists such action, all authorities agree; and although at first the gum imparts a slight taste to the water, this effect seems speedily to disappear.

There are many other circumstances which render tubes of this material very advantageous for the conveyance of water. It bears an amount of friction and hard usage which is frequently surprising. At New York there is a gutta percha pipe a thousand feet in length, which conveys the water of the great Croton Aqueduct to Blackwell's Island; the pipe lies along the bed of the intervening river, and is kept down by upwards of a hundred small anchors, and yet it resists both the friction of the bed and the weight of the anchors. With an immense pressure of water, gutta-percha pipes have been found to remain unharmed, where leather hose would be disrupted. It resists the action of marine insects, which would soon make ravages on stout timber. If water be contained in a gutta-percha pipe, it remains liquid at a temperature which would produce ice in almost any other pipes. For watering gardens and roads, for sprinkling malt in a kiln, for applying water from a fire-engine, these pipes appear to be singularly well fitted, since to a great power of resisting pressure, they may be bent, or twisted, or lengthened, or shortened, in any required degree. Nor is this material, *per se*, the only efficient part of such pipes; for a gutta-percha pipe may be firmly united to a metal pipe in five minutes, with no other cement than warm water; the end of the pipe being softened in warm water, and drawn over the end of the metal, the gum contracts on cooling so as to grasp the metal tightly, and thus form an impenetrable joint.

But if water be conveyed thus effectively through tubes of gutta percha, the qualities of the material are still more remarkably displayed in the conveyance of chemical liquids. Few persons are so ignorant of chemistry as not to be aware that the stronger acids and alkalies play sad havoc with the vessels and tubes which contain them. On the other hand, there is an obstinacy of constitution about this singular substance which enables it to baffle a whole host of formidable opponents. It does yield, certainly, to concentrated sulphuric and nitric acids; but if these acids in a weaker state be the liquids in question, or if muriatic, acetic, or hydrofluoric acids, or chlorine (all of which have a very destructive action), then the gutta percha stoutly resists them, and renders good service. Carboys, pipes, dye-vats, flasks, funnels, bowls, ladles, syphons, troughs, measures, buckets—all are now made of this material, for use in chemical works, print works, dye and bleach works, and other establishments where strong chemical liquids are employed.

To go from the region of waters to the region of airs, we find that gutta percha pipes are coming into use for the conveyance of street gas. Considering that this material is soon softened by heat, and that one end of every gas pipe is in near proximity to heat, it is probable that gutta percha will be less available for this purpose than for the conveyance of cold liquids. But for any *temporary* gas lighting, nothing can well be more convenient. Let a festival, an honorary dinner, a "grand demonstration," be given in a large building not usually lighted to any very brilliant extent; gutta percha gas-pipes can be arranged with great rapidity, owing to the ease with which they may be bent in any direction, and fastened to any other material. A very pretty applica-

tion is sometimes seen in workshops, where a gas-light can be carried by hand to any part of a room. One end of a gutta-percha tube is fastened to a gas pipe, and the rest of the tube is wound round a small block of wood like a tape-measure; this block has a handle to hold by, and a small metal jet for igniting the gas. This singular candlestick (or rather gas-stick) may then be carried about the room, uncoiling or coiling the tube as distance may require, without interrupting the flow of gas through it.

### Gutta Percha: its Acoustic Services.

The conveyance of *sound* is, however, the most extraordinary service which gutta-percha tubes have yet rendered. If there be (and perhaps there may be) any diversity of opinion in respect to water, chemical, or gas conveyance, there is and can be none respecting sound. No other substance has yet equalled gutta percha for acoustic purposes. Let us picture to ourselves an aged person, whose sense of hearing has become so far decayed that he is rendered unable to take part in the usual Sunday services in church or chapel, from inability to hear the voice of his minister; let us imagine (if it *can* be imagined by any except those who suffer) the desolation and isolation of such a position; and let us next suppose that the glad tidings were communicated to him, that by a modern contrivance he will be enabled (unless his degree of deafness be wholly beyond human aid) to hear the reading and the preaching in whatever part of the building he may be—would he not at first be utterly incredulous, and would not his heart leap for joy when he found it to be a sober undoubted fact? He might know nothing of Dr. Montgomerie, or of the Malays, or of Singapore, or of the Society of Arts, or of the inventors, or of the manufacturers; but he would bless them all if he found they could render him this service.

We will examine the simpler forms of gutta-percha acoustic apparatus, before describing the recent remarkable application in churches.

There are two qualities required in a speaking tube; first, that it shall concentrate a large amount of sound into a small space: and second, that it should not stifle the acoustic vibrations within the tube itself. Any material will answer equally well, so far as the first-named quality is concerned, for it requires simply a trumpet-shaped mouth at one end, and a very small orifice at the other; but gutta-percha possesses rare qualities in respect to the second kind of service. Whether it is the smoothness of the texture, or the peculiar kind and degree of elasticity, or the relation of the substance to heat or electricity—whatever may be the cause, a tube of gutta percha preserves sonorous vibrations with a surprising degree of clearness and equability; and the modes in which this quality are brought into useful requisition are already very numerous.

There is, for example, the *long ear-trumpet*, with a wide orifice at one end and a small one at the other; and there is the *portable ear-trumpet*, differing from the former only in bringing the speaker and the hearer closer together, by a "French-horn" system of twisting in the tube. There is the *ear-cornet*, so small and neat that one may be almost invisibly attached to or near each ear. There is the *paraboloid trumpet*, in which the sound is echoed from a large concave receiver before it enters the tube. There is the trumpet with a long flexible tube, or with several tubes, so that several persons round a table can communicate in turn with the user. In short there have been almost as

many useful variations of the principle as there are variations in the social inconveniences of those who require such aid.

A different group altogether is formed by those contrivances which are intended to aid—not partially deaf persons—but those whom noise or distance would otherwise disenable from conversing together. Take the case of a common London omnibus, with its rattle and rumble, and bang and confusion; it is a hard matter to carry on a conversation in such a vehicle; yet a small length of tube, with a slight expansion at each end, would enable two persons to converse in a tone inaudible to their neighbours. In a railway carriage the noise is generally still greater, and the service rendered more marked. Drivers of omnibuses now sometimes communicate with the conductors, and captains of steamboats with the engine-men, by gutta-percha tubes. But these are trifling services compared with such as the tubes render at greater distances. The *Domestic Telegraph*, as it has been called, is simply a gutta-percha tube conducted from one apartment to another: it is employed as a medium of transmitting messages, and saves many a weary footstep to those who are at the beck and call of others. The *Medical Man's Midnight Friend* (a lack-a-daisical sort of title) is a gutta-percha tube extending from the "doctor's" street-door to the doctor's bed, by which a message can be transmitted to the awakened practitioner instead of merely the sound of his bell. In factories and large establishments such speaking tubes are advancing extensively in favour; for the communication between distant buildings is most complete. In printing-offices, spinning and weaving mills, in union poor-houses, in hospitals and infirmaries, and in various other establishments of magnitude, the advantages are so self-evident that the use is becoming very general. At the Gutta Percha Company's works (a fitting locality for such a trusty messenger) a tube stretches across a wide open area which separates two clusters of buildings; to an eye below it looks merely like a thick wire, suspended in mid-air; but it is in effect a path-way for sound, a swift messenger, a secret confidant, an economizer of time, an insurer of accuracy, a merciful friend to men's legs and muscles. In a country town in Kent a shopkeeper has two houses on opposite sides of a street; he has had a gutta-percha tube laid down beneath the roadway, and the two halves of his establishment can chat with each other as though they occupied one room.

But to return to the church-acoustic apparatus, which is in many respects the most interesting and remarkable of these highly curious applications. Let us conceive, for clearness of illustration, that in a remote pew of a church is a person who, though not deaf, yet fails in ability to hear what is said in the pulpit or reading-desk. A gutta-percha tube is laid down either on or beneath the floor from the pulpit to the pew—the material bends so easily that it may be carried in any form—and a small ivory or hard wood ear-piece is attached to one end, while the other end expands in trumpet-form. Now the remarkable circumstance is, that the required effect is brought about without necessitating the approach of the speaker's mouth to the tube; his head may be two or three feet above, or below, or behind, or at the side of the trumpet-mouth; and yet the sound will reach the remote end of the tube in audible quantity. The truth is, that if the tube receives a *mouth-full* of sound (which it can in any direction round and near the speaker), that quantity is so economised, and so faithfully conveyed to the other end, that it becomes condensed to an audible pitch; if the trumpet-mouth be large, and the ear-piece very small, we may liken the action to the condensation of many threads of sound into one; and the ear of the auditor becomes sensible to

this condensed power. In practice, the trumpet-mouth is usually fixed to the front of the pulpit, mouth uppermost, and is stamped or moulded in an ornamental form consistent with the decorations of the pulpit. Beyond all this the sound may be *laid on*, like gas, to any pew or any quarter of the church; for there may be a tube (which we will call the main-pipe) laid along the centre aisle, and lateral tubes may spring from this to any required spot. Some clergymen have what they call a *deaf pew*; that is, a pew in which those are congregated who may be collectively benefited by this admirable apparatus. This contrivance has been used at some of the great meetings (four thousand strong) at Exeter Hall, by those to whom the speeches would otherwise have been little else than dumb show.

It does, indeed, seem as if one characteristic of our age were the annihilation of space and time. We may breakfast in London and dine in Plymouth. We make our gas at one spot, and light it many miles off. We turn a handle in London, and forthwith a signal is felt or seen at Edinburgh. We whisper in a tube in one building, and the whisper becomes audible in another scores of yards off. No matter what the agent be—steam, light, electricity, sound—we contrive so to bend it to our service as to enable us to run a match against time and space.

### Gutta Percha: its Telegraphic Services.

This mention of electricity reminds us that one of the most novel, striking, and valuable applications of gutta percha is that in which it forms an envelope for an electro-galvanic wire. We may regard such an apparatus either as a wire coated with gutta percha, or as a gutta percha tube with a wire running through it: the principle is the same under either aspect. The imperviousness of this material to water is the property which underlies this mode of application. In order that an electric current should pass along a copper wire, it is essential that the wire should be insulated, or surrounded by a medium which will not attract the current from its direct course. Gutta percha is eminently such a medium; and hence the wire, when so coated, is in the best possible condition for conveying the current. The submarine telegraphs owe their efficiency to this principle: the copper wire being completely enveloped in a casing of gutta percha.

It can hardly be necessary to give here any detailed account of the remarkable "submarine" enterprise of last year, or of the plans for the future; for they belong only incidentally to the subject of this paper. It will be remembered, however, that after much negotiation with the French authorities, an English Company actually laid down a telegraphic wire in the sea from Dover to a point near Calais. On August 28, 1850, a communication was made between England and France in this way, and one or two messages transmitted. The wire, which was twenty-one miles in length, had a thickness of about one-tenth of an inch, and was enclosed in a solid cylinder of gutta percha half an inch in diameter. The weight of the wire was about twenty-two cwts., and that of the gutta percha with which it was coated eighty-seven cwts. It was at that time hoped that telegraphic communication, by this means, would be permanently established between the two countries by the date of the opening of the Great Industrial Exhibition. Various circumstances have tended to retard the realisation of this hope; but we may reasonably look forward to it ere long. Nay, we may even see the day when a flash of lightning will cross the Atlantic, clothed in a tube of gutta percha.

A highly curious experiment has been recently made at the Gutta Percha Company's Works, which seems to show that *blasting* will receive the same kind of aid from this material as electro-telegraphing. A barge was moored in the Regent's Canal, alongside the quay of the works; and around the edges of this, dipping into the water, were coils of wire to the extent of seventy miles. The wire was of copper, coated with gutta percha; it was about the thickness of an ordinary black-lead pencil, and was of the same kind as that destined to be used for the submarine telegraph across the British Channel. A cartridge was adjusted to the wire at one spot, and the two ends of the wire were connected with the poles of a galvanic battery. The instant the contact was made an explosion took place, the current having passed through the seventy miles of wire in an inappreciably small space of time. If it can travel seventy miles, it can travel much more; if it can explode a small cartridge, it could explode a large body of powder; and it is as yet difficult to guess the number and variety of valuable purposes to which the method may be found available. Submarine blasting by electricity has been before effected, but not through such an immense length of wire as this.

## Gutta Percha: Diversified Application, in Sheets and Masses.

It is observable in many departments of manufacture that the material operated upon is brought to the form of *sheets*, before being fashioned for permanent use. This has especially been the case since rolling mills have come into general use. Many advantages result from such an arrangement; for the equability of thickness in the sheet enables the operator to adapt it to almost countless forms and purposes. Gutta percha is one among the list of such substances; and as we have already glanced at the curious and diversified application of this material in the form of *tubes*, so may we next bestow a little attention on its uses when fashioned into sheets.

The sheets, as was before noticed, may have any desired thickness, from that of paper to an inch or more, and are procurable in considerable lengths and widths. But, in truth, the extraordinary facility with which this substance may be joined—edge to edge or surface to surface—renders attainable almost any size or form of product.

If a gutta-percha pipe be fitted for the conveyance of water, why should not gutta-percha sheet form an advantageous lining for cisterns? The question has been asked, and the answer is now being given by the extensive use of such a lining. The simplicity of the application is quite remarkable. If we suppose a wooden cistern thus to be treated, five pieces of sheet gum are cut to the sizes for the bottom and sides; these being held temporarily in their places, bands or strips of gutta percha are softened in hot water and laid along the joints, to which they are firmly united by the application of a hot iron. The principle, indeed, is that by which the plumber solders two sheets of lead together; but the process is altogether much more facile and expeditious. For ordinary cisterns, the thickness somewhat exceeds an eighth of an inch, and such a sheet weighs six to eight pounds per square yard. There is thus a cistern within a cistern, for the gutta percha does not adhere to the wood; the wood, in fact, acts simply as a case or envelope, to keep the real cistern in shapeable and efficient order.

Another form into which gutta percha sheeting is wrought, on account of its admirable qualities when in contact with cold liquids, is that of pump

buckets and valves. The gutta percha advocates give leather buckets and valves a bad character; they say that such articles cannot be made without a seam or raised joint, that water often softens the stitching of the seams, that the leather is affected by acids and alkalies, and that the articles require frequent repair; whereas these same buckets and valves, if made of the formidable modern rival to leather, have no seams or raised joints, are never softened by cold water, are (for the most part) not affected by acids and alkalies, are very durable, and are easily and cheaply repaired. As counsel on the other side are not present, we must not venture on a verdict; but it may perhaps safely be stated that gutta percha has realised almost all that has been anticipated for it, so far as concerns its services when in contact with cold water or other liquids.

But the leather interest is attacked in its stronghold when gutta percha claims a place in our boots and shoes; the battle here becomes an important one, and must be fought fairly and honestly. As to the claims put forth, no one has a right to pass judgment on them except after a long and steady trial; whether gutta percha soles are cheaper, more durable, and more easily repaired than those of leather, and whether they keep the feet dry in wet weather and warm in cold weather—must be decided by each wearer for himself. If all this be really the case, nothing can prevent the extended use of such substitutes for leather. The oddity of the matter is, that "every man his own cobbler" may be adopted as a maxim in the case; for the fixing of gutta-percha soles, as of everything else made of this remarkable substance, is readily effected. The sons of Crispin may, however, still comfort themselves with the fact that "upper leathers" remain pretty much within their own domain; although even here india rubber and gutta percha are beginning to invade it.

But if a biped can be shod with gutta percha, why not a quadruped also? Will this material suffice for horse-shoes? Perhaps not, considering the severe usage to which such shoes are exposed. But there has lately been devised a curious and very useful application of gutta percha to the horse's foot. When a road is newly coated with broken flints, the fragments have a tendency to cut and injure the foot of this trusty animal in the sunken portion within the iron shoe. A sole of leather is sometimes applied as a protection; but gutta percha, from its plastic character when warmed, is capable of being pressed into the commissures and cleft of the "frog" of the foot, so as to adhere closely to all the exposed portion of the foot. And yet, at night-time, or whenever deemed desirable, this shield may easily be removed, and adjusted again by slight warming.

There is a peculiar application of gutta percha which, though well understood in manufacturing towns, is not very familiar to general readers. We allude to wheel bands for machinery. When a shaft or wheel is rotating, another shaft or wheel at a considerable distance may be made also to rotate, by carrying an endless band from one to the other, and making it coil tightly round both; the first wheel causes the band to rotate, and this in its turn communicates similar motion to the second wheel. Now these bands, until within the last few years, have generally been made of leather; but gutta percha is found to possess many qualities available for this purpose. A strip of the required width is cut from the sheet, and the two ends of this strip are joined, so as to form an endless band. The qualities which seem to adapt this material for such purposes are the durability and strength, the permanent contractibility, the uniformity of substance, the power of resisting water, acids, alkalies, oil, and grease, and the facility of making joints. The bands

are now used to a considerable extent in breweries, bleach and dye-works, cotton and woollen-factories, iron-works, paper-mills, corn-mills, brick-yards, and other large establishments where much wheel work is employed.

It seems a very reasonable conjecture, that the peculiar properties of gutta percha would render it a valuable material for boats—not perhaps the every-day boats for commercial and nautical purposes, but those intended for some special service. When Lady Franklin fitted out an expedition in search of her gallant husband, a year or two ago, Captain Forsyth, the commander of the vessel, took out with him a gutta-percha boat, presented for that purpose by Messrs. Searle. His account of the behaviour of this boat, under the rough usage to which it was subjected in the ice-bound regions of the north, is most laudatory. He states that, "whilst the other boats constructed of wood suffered much by the cutting of the young ice, the gutta-percha boat was not in the least damaged, and returned to England in almost as good condition as when she left, although she underwent all the rough work of the voyage." Mr. Snow, who had especial charge of the gutta-percha boat belonging to the "Prince Albert," has detailed in a clear manner the remarkable way in which this material resists the rude buffetings of those regions. It must be remembered that the boat had a skeleton of wood and a covering of india rubber. Mr. Snow says, "The severest trial it endured, and endured successfully, was on both my visits to Whaler Point, Port Leopold. To those unaccustomed to the nature of such ice as was there met with, it will be impossible fully to conceive the position a boat was placed in. The mere transit to and fro, among loose masses of ice, with the sea in a state of quiescence, would have been quite enough to have proved or not the value of gutta-percha boats; but when, as in the present case, those masses were all in restless agitation, with a sea rolling in upon an opposing current, it might have been well excused—and without deteriorating from the previously attested goodness of the article—if it had not been able to have resisted the severe shocks it received. . . . . . Sliding through and over the ice; sometimes lifted completely out of the water by the sudden contact of a restless floe; and at others thrown sideways upon an adjoining craggy piece; I think it would have been next to impossible for any other kind of boat to have been otherwise than crushed or stoved on the instant." It was in a right spirit that the explorers gave the name of "Gutta-Percha Inlet" to the spot where the boat had rendered them such important service.

In the plentiful sprinkling of salt water to which a hard seafaring man is exposed, it seems not unreasonable that gutta percha would be found serviceable in a great variety of ways on board ships. Accordingly, we find that a ship's fittings and a sailor's "kit" may now comprise a diversified list of articles made in this material. Most of them are manufactured from sheets of greater or lesser thickness, but some are wrought in other forms. For some of such purposes gutta percha is valuable because it is waterproof; for some, because it is unaffected by salt water; for others, because it is not liable to fracture when thrown down or when dashed against rocks; and for others, because it is readily moulded into any form by the application of heat. Here we see it as a "sou'-wester," or as a pilot's hat; as a life buoy; as a lining for water tanks; as a jug or a basin for holding water; as a pump hose or a pump-bucket; as a sheathing for ships; as a speaking trumpet; as a float for fishing nets; as a waterproof covering; as an air-tight life-boat cell; as a cord or a line; as a lining for boxes and trunks; as a flask or a bottle; or as a chart case. The strange diversity of these uses is sufficiently apparent. If a sailor

had been told, some years ago, that a time would arrive when he might have his hat, his wash-hand bowl, his tiller-rope, his speaking-trumpet, his life-buoy, and the sheathing of his ship, all made of the same material, he would have deemed it a landman's joke, fitted only for "the marines."

Medical practitioners are daily finding that gutta percha is applicable to a number of purposes incident to their professional duties. A thin sheet or lining of this material is employed as a wrapping in rheumatism and gout. A thicker sheet forms excellent splints or supports for fractured bones, or limbs under surgical treatment. As a stethescope or chest-explorer, a gutta-percha tube is said to be very effective; for though a capital conductor of sound, it conducts heat very slowly.

A rare catalogue we should present, if all the useful applications of gutta percha were duly set forth. We should have to speak of breast-coating for water-wheels, of galvanic batteries, of shuttle-beds for looms, of packing for steam-engines and pumps, of cricket and bouncing balls, of felt-edging for paper making, of curtain rings whose merit is *noiselessness*, of window-blind cord and sash lines, of clothes' lines (recommended to the laundress as defying all attacks of weather), of bosses for flax-spinning frames, of whips and sticks, of policemen's and "special constables'" staves, of flax-holders for heckling machines, of skates, of fencing sticks, of washers for the axles of wheels, of plugs or solid masses used in buildings, of buffers for railway carriages, of gunpowder canisters (which "keep the powder dry"), of sheet-covering for damp walls, of linings for ladies' bonnets, of jar covers, of sponge bags, of foot baths, of funnels, of goldsmiths' bowls, of bobbins for spinning machines, of covers for rollers, of book covers, of moulds for electrotypes, of coffin linings, of sounding boards, of portmanteaus, of beds for paper-cutting machines, of fine and coarse thread, of envelope boxes, of powder flasks, of portfolios, of a stopping for hollow teeth—a tolerable list, this, which shows how multiplied are the applications for which this singular vegetable product is available.

## Gutta Percha as a Decorative and Fine-Art Material.

Widely apart from the various applications of gutta percha described in the preceding paragraphs, are those in which ornament rather than utility is the main purport in view. To dissever ornament from utility is neither needed nor to be wished; the two ought to be linked hand in hand; but the difference of character here intended to be implied will be easily apparent.

Admirably does this substance show itself to be adapted to such purposes. When softened by heat, it will take the impress of a mould or stamp with delicate precision; and in the course of a few minutes it reassumes its tough state, retaining permanently the pattern given to it. The power of application is thus unlimited, or limited only by the inclination of the purchaser. Whether the mould be of copper or of brass, of pear-tree or of box, an impress can equally well be obtained from it. In practice, all these four materials are employed, and sometimes others. The mould being carved and in a state of readiness, the piece of gutta percha (always, or nearly always, in the form of sheet) is laid upon a marble slab, which is heated by steam from beneath; and the gum being thus brought into a pliant and yielding state, it is placed on or in the mould, a counter-mould is laid upon it, and the action of a press forces the material into the minutest parts of the device. If the pattern be deep and the relief bold, a hydraulic pressure of a hundred or a hun-

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## Gutta Percha as a Decorative and Fine-Art Material.

Widely apart from the various applications of gutta percha described in the preceding paragraphs, are those in which ornament rather than utility is the main purport in view. To dissever ornament from utility is neither needed nor to be wished; the two ought to be linked hand in hand; but the difference of character here intended to be implied will be easily apparent.

Admirably does this substance show itself to be adapted to such purposes. When softened by heat, it will take the impress of a mould or stamp with delicate precision; and in the course of a few minutes it reassumes its tough state, retaining permanently the pattern given to it. The power of application is thus unlimited, or limited only by the inclination of the purchaser. Whether the mould be of copper or of brass, of pear-tree or of box, an impress can equally well be obtained from it. In practice, all these four materials are employed, and sometimes others. The mould being carved and in a state of readiness, the piece of gutta percha (always, or nearly always, in the form of sheet) is laid upon a marble slab, which is heated by steam from beneath; and the gum being thus brought into a pliant and yielding state, it is placed on or in the mould, a counter-mould is laid upon it, and the action of a press forces the material into the minutest parts of the device. If the pattern be deep and the relief bold, a hydraulic pressure of a hundred or a hun-

the two termini and half a dozen intermediate stations, and provided for the transmission of signals from every station to every other, at intervals of a quarter of an hour throughout the day. The rope has died a natural death, and given way to locomotives; but the telegraph has gone on increasing in importance year by year.

The same inventors who introduced the first telegraph have improved it by subsequent patents, and have (among other things) devised a mode by which it may print its own indications. In the mean time foreign nations were not blind to the wonders thus gradually developed; Professor Morse in America, and Dr. Steinheil and others in Germany, devised forms of electric telegraphs in which much novelty and ingenuity were displayed.

The first experimenters employed a return wire to complete the galvanic circuit; but it has since been found that this may be dispensed with. In 1842 Mr. Bain conducted an experiment at the Serpentine, in which he made the water itself perform the part of the return wire. Professor Wheatstone, about the same time, laid down a telegraphic wire from King's College to the shot tower nearly opposite, and completed the circuit by the water of the Thames.

Long before the Electric Telegraph Company was established, public attention had been attracted to the marvels attained in quick communication of intelligence. The Queen's speech was printed at Southampton within two hours after its delivery in London; the substance of it having been transmitted letter by letter. A murderer, whose crime had been committed at Salt Hill, was captured in a railway carriage at Paddington, the news of his crime having travelled quicker than even railway travelling could carry him; the dread messenger, with lightning speed, passed silently through the wire suspended near him, and overtook him in his attempted escape from justice. Games of chess were played by persons a hundred miles apart: each move being signalled by the telegraph. A deserter from the United States army, who had doubled his offence by robbery, was captured in a similar way on the Washington and Baltimore Railway. A physician at Lockport corresponded by similar agency with a patient at Buffalo, many miles distant; the one transmitting an account of his symptoms, the other forwarding his advice and prescription. But the oddest of all was a marriage ceremony, performed between a bridegroom at New York and a bride at Boston; the questions and answers and declarations and pledges being transmitted per telegraph: the match being a stolen one, however, the validity of the ceremony was afterwards disputed in a court of law.

Dr. Steinheil, Professor Morse, and Mr. Davy, all contrived electric telegraphs which would write or print their own indications, and this even very early in the history of the art. But from various practical difficulties, the registering apparatus has not been so much employed as was at first anticipated. Professor Morse made his instrument write with a pencil, in arbitrary characters formed of lines and angles; but in a later modification, the characters were made by indentations on the paper with a blunt instrument. Mr. Davy contrived to produce a series of blue lines on white paper, as a set of symbols.

It would be no easy matter to trace the rapid succession of improvements and novelties in this wonderful apparatus. The wits of men were sharpened both by the beauty and the value of this new intermedium of thought; and we find a continued stream of inventions, some patented and some not. Mr. Wheatstone patented a third modification in 1840, supplemental to those of 1837 and 1838. In 1841 Mr. Bain brought forward his electric telegraph,

with a printing apparatus for recording the results by ordinary inked types; and in 1843 he applied various modifications to the system. In 1843 Mr. Cooke introduced the mode of suspending the wires on posts, which has since been so generally adopted on English railways. A year or two after this, Mr. Bain devised a new form of registering or writing telegraph, in which the written copy produced at one end of the wire is an exact counterpart or facsimile of that transmitted from the other. Then came various improvements by Messrs. Brett and Little, in almost every part of the apparatus; by Messrs. Henley and Forster, in the details of the magnetic machine; by Mr. Ricardo (Chairman of the Electric Telegraph Company), in the mode of insulating and suspending the wires; by Mr. Swan, in the acid liquid employed in the batteries; by Dr. Bachoffner, chiefly in the indications by means of a dial; by Mr. Bakewell, in his very ingenious transmitting apparatus; by Mr. Roe, in the mode of using metallic types; by Mr. Bain, again (who, in 1849, attained the means of printing one thousand letters per minute by his electric telegraph); by M. Dujardin, in the chemical printing arrangements; by M. Pulvermacher, in various parts of the apparatus; by Mr. Highton, who sketched a multiplicity of minor changes; by Messrs. Brown and Williams, in the adjustment of the electro-magnetic machine; by Mr. Siemens, in the mechanical details of the magnets and the printing types—indeed, considering the expense of a patent, it is astonishing what a number have been taken out on this subject; for most of the above lists are patented, and only a few out of the number are likely to bring golden results to the patentees.

The Electric Telegraph Company, mentioned in the preceding paragraph, was formed in 1846. It has purchased most of the patents of Messrs. Wheatstone and Cooke, and of Mr. Bain; and is up to the present time the only body by whom electric telegraphy has been carried on to any great extent in this country. The central office is in Lothbury, from which point wires extend to the various metropolitan railway termini, and from those termini the wires ramify to almost every part of England and Scotland wherever a railway exists, always excepting the mighty "broad gauge," which seems to have a will and a way of its own in everything, and to distrust imitation of its narrow gauge neighbours. The broad gauge is, however, at length yielding to the electric pressure from without; for orders have lately been issued for laying down the telegraph on that important system of railways. As for the *modus operandi* at the various telegraph offices, most persons have seen, or heard, or read something concerning it. A person takes a written message to the office; it is dissected into letters, and transmitted piecemeal; it is received at the other end of the wire, and is built up again into the form of a message; and this message is conveyed to the required quarter. Generally speaking, the messages relate to matters of business, making enquiries, transmitting news, &c.; but they may obviously relate to other matters. A few weeks ago, a military officer had to attend a royal banquet in London; he came from the north, per railway, but found that he had left his regimentals behind him; he was for hastening back at express speed to fetch the indispensable symbols of his rank, but was told that an electric message would save him all the labour, half the time, and nearly all the expense; and the glittering attire was sent up to him by the next train.

The Telegraph Company, after an existence of fourteen years, has recently applied for an extension of the monopoly rights, on the ground of the large sums paid in purchase of patents. But this application has been refused, and

a new company established by Act of Parliament. Hostilities have not yet actually commenced between the rival powers, but it is pretty sure to arise ere long. The directors state that sufficient capital has been provided by shareholders to construct a thousand miles of telegraph on the new system, which is said by its advocates (as advocates always say) to be much superior to the old. Negotiations are on foot with the various railway companies; each telegraph company seeking to outbid the other in offers made for the use of the railway lines: the profits to be derived from letting out the use of the telegraph for commercial purposes. If this competition do not degenerate into recklessness, there may be enough financial success for both, and the public may be well served; but the difficulty consists in maintaining the distinction between wholesome and unwholesome competition.

But the *submarine* telegraph is that which now most rivets public attention: it is so marvellous, and will be of such incalculable advantage if successful. Where and when the subject was first broached we do not know, but in 1844 a Jersey newspaper threw out a suggestion that a submarine telegraph might possibly be laid down from that island to Southampton. In 1845 an American newspaper—the country for daring "go-ahead" journals—gave a string of calculations to show that an ocean telegraph from England to America was practicable. This was a matter in which the Admiralty felt an interest; and partly for their immediate uses, partly to test the larger project, they caused a submarine telegraph to be laid down from Gosport to Portsmouth, across Portsmouth Harbour. The perfect success of this project made a great impression on the public mind; and hence projectors became abundant—Dover to Calais, Holyhead to Dublin, Marseilles to Algeria, England to America—nothing came amiss to these oceanic telegraphers. In the beginning of 1849 the Electric Telegraph Company laid down wires from their office at Hull to the new railway station, and passed it at a depth of twenty feet beneath the water through one of the docks; this was a submarine (or at least subaqueous) telegraph on a small scale, and succeeded perfectly well. A "Dublin and Holyhead Submarine Electric Telegraph Company" was projected and advertised in the same year; but shareholders do not appear to have been forthcoming. In the same year, also, the French Government granted a privilege to Mr. Jacob Brett to lay down a submarine telegraph from France to England: the Government to derive certain advantages from it, and the contractor to have the commercial monopoly of the system for ten years. One of the conditions of the contract is said to have been, that by the aid of a single wire, and of an observer on each shore, the apparatus should be capable of printing on paper, in clear Roman type, 100 messages of 15 words each, in 100 consecutive minutes.

It was a day to be remembered, when this thread of thought (if it may so be termed) was first stretched across the Channel from England to France. On the 28th of August, 1850, this was actually effected; and although circumstances have retarded the completion of the system, the soundness of the principle was abundantly tested. The wire employed was of copper, encased in gutta percha; about thirty miles of such wire was coiled round a large cylinder in the steamer *Goliath*. One end of the wire being secured on shore at Dover, the steamer slowly voyaged across the Channel to Cape Grisnez, a point on the French coast midway between Calais and Boulogne; the wire uncoiled as the vessel proceeded, and sank to the bottom of the sea, where it was kept down by leaden weights placed at intervals. Onward the steamer proceeded, while those on board kept up a fire of telegraphic questions and answers with

the friends left behind at Dover; a strange defiance of distance and of waves! At length the vessel reached the French coast, and the line was carried up a cliff, where it was placed in connection with a battery. Complimentary messages were then transmitted between England and France; and thus was achieved one of the greatest triumphs of science in its applications to the wants of society. It is true that the wire was broken by an accident within a week afterwards; it is true that a whole year has not sufficed to re-establish the system on an enduring basis; and it is also true that the arrangement now in progress involves very formidable augmentations to the weight and costliness of the apparatus employed; but it cannot be doubted that the great difficulty has been surmounted: the principle and the leading practical details are sound; and engineers are not the men to be beaten by such difficulties as those which yet remain. A company of capitalists has, we believe, been formed for carrying out the project, and the wires have recently been completed. They consist of copper wires, each imbedded in gutta percha, and the whole then inclosed in an iron wire cable. The whole apparatus is of immense weight, and is (at the time this sheet is being printed) about being taken out to sea. To lay this ponderous mass down from shore to shore will be an operation likely to tax all the skill of the engineers.

In the beginning of 1851 a paragraph appeared in *Galignani*, which seems to show that Mr. Bain's system is working more energetically in that country than our English system. The French Government, preparatory to purchasing Mr. Bain's rights so far as regards that country, caused a trial to be made on the Paris and Tours Railway. "A signal was made from the ministry to Tours, desiring that a despatch might be forwarded to Paris. This communication, and the answer from Tours, a distance of about 180 English miles, announcing that a despatch would be sent immediately, took one minute and a quarter. A long despatch, containing 460 words, equal to about fifty lines in the ordinary print of a newspaper, was then received. The time occupied in the transmission of this long despatch was only two minutes and a quarter. It was read off by one of the assistants, and written down by another at his dictation, in thirteen minutes. The signs were read with the same facility and rapidity as another person would read the ordinary print of a book." Unless some error has crept in here, such a performance is most marvellous.

Great as may be deemed the length of electric telegraph in England (for it is adopted on most of the narrow-gauge railways), it is wholly thrown into the shade by that of the United States, where it is measured by thousands of miles; some on Morse's system, some on that of Bain. Even Mexico, poor shattered Mexico, has spirit enough to have lately commenced a line of telegraph from the Capital to Vera Cruz on the one side, and to Acapulco on the other; thereby stretching a wire across the country from ocean to ocean. British America, too, is rapidly running a line from Montreal to Halifax. On the continent of Europe, Siemens and Halske's system is adopted in the greater part of Germany; it combines a writing and printing power with that of telegraphing, exhibiting great ingenuity. In Austria, where the railways are creeping towards the Adriatic in one direction, and towards eastern Europe in another, the electric telegraph appears as their companion; and so it is in such other parts of Europe as have begun to adopt the railway system; nay more, telegraphs are, in some continental countries, laid down beneath the common roads without waiting for railways. Thus it proceeds, step by step, across Europe. Lord Palmerston made a pleasant prediction, or a joke which may turn out to be a prediction, at a public dinner at Southampton, where he

said that the day may come when, if the minister were asked in the House of Commons whether war had broken out in India, he might answer, "Wait a minute; I will telegraph the governor-general, and ascertain."

## Electric Bells and Electric Clocks.

A sister invention to the Electric Telegraph now presents itself to our notice, in the very remarkable clocks which derive their characteristic features from this wonderful but invisible agent. Clocks and bells have been subsidiary adjuncts to many electro-telegraphic contrivances. Bells were introduced some years ago, in certain public establishments, connected with the apparatus on Professor Wheatstone's principle. A single small battery, or small magnetic arrangement, is sufficient to ring all the bells of a large establishment, by conducting a small wire from the machine to the bell. A *touch* instead of a *pull* suffices to ring a bell so arranged.

The electric clock is not, as some suppose, a clock in which electricity replaces wheelwork and pendulums: it is not so entirely magical. What it will really effect is this—if one clock be going correctly, any number of other clocks may be made to borrow their indications from it, with very little other mechanism than hands and a dial. It is not so much a *production* as a *transference* of time-measuring indications. In Mr. Wheatstone's first electric clock, for instance, shown in action to the Royal Society in 1840, there was a primary clock with a few extra adjustments, a galvanic battery, a skeleton clock without any mechanism for the maintaining or regulating power, and conducting wires to connect the whole together. The primary clock gave correct time, and ingenious contrivances enabled these indications to be imitated on the skeleton clock, through the medium of galvanic agency conducted along the wire. The principle was made very apparent, that a single clock may be made to indicate the time in as many different places, distant from each other, as may be required. In an astronomical observatory, for instance, every room may be furnished with an instrument which will copy exactly the indications of the primary astronomical clock set up for the use of the establishment.

A very striking illustration of the use of this marvellous agency in connection with clocks was given in the United States in 1847. It was not an electric clock, but a peculiar employment of two clocks and an electric telegraph. Two astronomical clocks, at New York and Washington, were accurately adjusted to solar time at those two stations, and an electro-telegraphic wire extended from the clock room at one station to the clock room at the other—a distance of 225 miles. At a given moment, say precisely at noon, a signal was sent from New York to Washington, stating the exact time; this signal was received instantaneously, or at least after an interval too short to be appreciated, and immediately compared with the indications of the Washington clock. The two clocks were thus compared at a given instant, although so far asunder; and the difference of the indications measured the difference of longitude between the stations: this difference was found to agree almost exactly with that determined by astronomical and trigonometrical operations. Depending on the same principle, though modified by different circumstances, is the paradoxical receipt of a message *earlier* than it has been delivered—one of the most curious among the "curiosities" of electricity. On the morning of New Year's Day, 1845, a second or two after an accurate clock had struck twelve, a message was sent by the electric telegraph from Pad-

dington to Slough: this message was received in 1844 by the observers at Slough! The truth is, that as Slough is westward of Paddington, its clocks are later or slower in the same degree; so that the Slough clocks had not yet struck twelve, and the year 1844 had not yet expired. Of course, in this instance, the clocks indicated local time, and not railway or Greenwich time.

For some reason or other, or perhaps for a combination of reasons, the electric clock has not been made so practically available as the electric telegraph. Many years passed over without much advance on Professor Wheatstone's arrangement. A certain inconstancy and varied intensity in the electric power by which the pendulum is kept in oscillation is one main difficulty in the way. Two or three years ago Mr. Appold sought to remove this evil through the aid of a self-adjusting apparatus connected with the pendulum, which should allow the current to flow only when required, and then only in such quantity as becomes necessary to restore the pendulum to its mean rate of vibration. Mr. Bain, also, who has perhaps been the most indefatigable of all inventors in the application of electricity to telegraphs and clocks, has steadily followed out plans for removing one by one the difficulties which present themselves Few contrivances can be more remarkable than Mr. Bain's electric clock. It has no weight, no spring, no escapement, no winding-up apparatus nor necessity for being wound up, no agency within itself for putting or keeping the hands in motion. The invisible power which actuates it is outside the clock—outside the house, even, in which the clock is contained. In a garden or other piece of ground is dug a hole four or five feet deep; into this hole is thrown a layer of coke, then a layer of earth, and then a few zinc plates. A feeble but constant galvanic current is generated by the contact of the earth with the coke below it and the zinc above it, without the aid of any other battery; and this current is conveyed in-doors by copper wires. The wires form a coil round a magnet; and the electro-magnet thus formed is made to constitute the bob of the pendulum of the clock. Delicate and beautiful mechanism enables the electric apparatus to give a vibratory motion to the pendulum, and the pendulum in its turn to give motion to the two hands of a clock. The only "winding-up" required by this extraordinary clock is a feed of zinc to the earth-battery when it shall have become oxidized by long use; but one of the clocks has been already known to go three or four years without any such chemical winding-up. This is not "perpetual motion," certainly, but it is a most instructive approximation towards it.

It was in 1849 that Mr. Shepherd, the chronometer maker, obtained a patent for that form of electric clock which has since become familiar to so many thousands of visitors at the Crystal Palace. In the first place there are eight electro-magnets to give moving-power to the clock. Each magnet consists of a bar of iron with about three thousand feet of wire coiled round it; so there are nearly five miles of wire in all. The mode in which the electric current is brought into operative connection with the works of the clock is novel, but too intricate to be made intelligible without diagrams; we therefore go to the outside of the south transept. Here we find a clock-face of singular character: instead of being a circle it is a semicircle, and each hand extends across the diameter instead of merely the semi-diameter. This novelty seems to have been chiefly due to the architectural arrangement of that part of the building. The minute hand is sixteen feet long, and the hour hand twelve: the former revolves once in two hours, and the latter once

in twenty-four. Six o'clock, instead of being marked at the bottom of the face, is at the right and left, or east and west; and the observer is at first a little puzzled to learn the indications; but they soon render themselves familiar. There are no heavy weights in the clock, and the space which it occupies is very small, although it is said to equal that of St. Paul's in power.

A smaller clock, in front of the south transept gallery, within the building, is worked by the same battery as the larger one; and—still more fitted to illustrate the way in which electric agency defies distance—there is a third clock in the western gallery, eleven or twelve hundred feet distant from the first. All three work together, giving like indications, and linked by this mysterious sympathy.

Of the kindly relations which exist, and must ever exist, between science and its applications, we have already spoken; and instances illustrative of these relations are daily multiplying around us. For instance, at the recent Ipswich meeting of the British Association, evidence was afforded of two pleasant and important facts—that electricity is likely to be a most important aid in astronomical observations; and that America is busily and successfully prosecuting astronomical studies, in spite of Californian gold and other sources of excitement. Professor Bond contributed a paper on the application of electro-mechanism to astronomical observations, as practised at Harvard Observatory. Supposing the observer wishes to note the exact instant when a star passes the meridian; he has an accurate clock near him, and an electro-magnetic machine in connection with the clock; he has also a piece of paper wrapped round a slowly revolving cylinder. He touches a key at the instant of the transit; this connects the machine, the clock, and the paper together; and a mark is made on the paper in such a way as to indicate the exact instant of the transit. A permanent record is thus obtained, which can be preserved by removing the paper from the cylinder. The great authority of the Astronomer Royal tells us that "the principle of the method is entirely the discovery of the Americans, and that Professor Bond has the merit of originating what he (the Astronomer Royal) had no doubt would prove of the utmost importance in the practice of astronomy."

## Electric Rivalry to the Steam-Engine.

An opponent has sprung up to the system which we owe to the genius of James Watt. Electricity has given a formal challenge to steam, and engages to try strength against it in the mill, in the ship, and in the railway. The challenge is a bold one, and must be fairly met.

It is now about eighteen years since the idea of working machinery by electric power was first practically tested. There may, it is true, have been some earlier attempts; but the late Mr. Sturgeon, at any rate, exhibited a small galvanic apparatus in 1833, which was capable of pumping water, sawing wood, and performing other mechanical operations. Although a mere toy as to size and power, it clearly illustrated the principle under notice, and was so far important. Three or four years after this Dr. M'Connell, of Pennsylvania, made a small electro-magnetic machine which gave motion to a fly-wheel: although the machine weighed but seventeen pounds, the wheel carried a load of forty pounds through a space of 300 feet per minute, and was made to rotate seventy times in that space of time.

Other inventors in other quarters were not slow to follow the path thus laid open. One of them was Mr. Clarke, of Leicester, who constructed an electro-

locomotive which ran on a circular railway, and drew from sixty to one hundred pounds weight; instead of a "feed of corn," or a "charge of coke," its stamina was kept up by three pints of acid liquor in the galvanic apparatus, for two hours' work. Another ingenious experimenter was Professor Jacobi, of St. Petersburg. In a paper read at the Glasgow Meeting of the British Association in 1840, he detailed the particulars of a very novel voyage which he had made on the river Neva in the preceding year. He constructed in 1838 a tiny steam-boat, or rather magneto-boat, about thirty feet in length, seven or eight in diameter, drawing three feet of water, and capable of holding fourteen persons; it had a galvanic battery instead of a steam-engine; and this battery was made to act on paddle-wheels, by which the boat was propelled. He obtained a speed of a mile and a half an hour, on the first trial; but, by various changes, in the next following year he raised the speed to three miles an hour—humble, perhaps, but not contemptible as a beginning. "We have gone thus on the Neva," the Professor wrote, "more than once, and during the whole day, partly with and partly against the stream, with a party of twelve or fourteen persons, and with a velocity not much less than that of the first-invented steam-boat." It was, in truth, a very creditable beginning.

Shortly after this, another ingenious explorer in the same field appeared in Scotland. Mr. Davidson, of Aberdeen, constructed a small galvanic machine whereby a common turning-lathe could be driven; and the velocity obtained was sufficient for the turning of small articles. In another form of apparatus, the same inventor managed, with only two electro-magnets and one square foot of zinc surface, to generate power sufficient for drawing a small carriage with two persons over a rough floor. There was so far a fair trial given to the project, even in 1842, as to place a locomotive on the Edinburgh and Glasgow Railway at the service of the inventor, who propelled it at the rate of four miles an hour, solely by electro-magnetic agency.

So busy has been the search after this remarkable agency, that not a year has passed since the date of Mr. Davidson's experiments without producing something or other bearing on the subject. In one instance we have an inventor who is so sanguine that all is as he would wish it to be, that he predicts the speedy downfall of steam-power, never again to rise, before the younger giant—electricity. In another, we find an ingenious arrangement of mechanism described, but with more modest anticipations on the part of the inventor. In others, again, the plans exist only on paper, and have never yet been tried in the crucible of experiment.

In the year 1849 these projects began to assume a somewhat more definite form than they had hitherto presented. M. Hjörth, a Dane resident in England, obtained a patent for an application of electro-magnetic power to the purposes of engines, machines, ships, and railways. There were batteries to generate the power, magnets to be influenced by the power thus generated, and mechanism to apply the power to the rotation of a fly-wheel, which became in its turn the source of motion to other machinery. He planned an engine, intended to be of ten-horse power; one of his electro-magnets was of enormous power; and bright anticipations were indulged in concerning the results. The visitors to the Crystal Palace have had an opportunity of seeing M. Hjörth's machine, or at least a model of it; but we are not aware that anything has yet occurred in realization of the inventor's enthusiastic hopes.

The same year witnessed the introduction of M. Pulvermacher's electro-magnetic contrivances. This gentleman is an Austrian, but he obtained an English patent, in which a very wide range of ingenious inventions are de-

scribed. There are new materials for the cells of the galvanic battery; new arrangements for conveying away the acid fumes generated during the galvanic action; new modes of rendering the current uniform in strength; new combinations of fluids in the battery; an arrangement of apparatus for producing mechanical power; an electro-magnetic locomotive; and a new form of electric telegraph—the whole comprising many ingenious novelties.

Another aspirant to public favour in the same field is Professor Page, of America. In a series of lectures which he delivered before the Smithsonian Institution in 1850, he described certain arrangements of electro-motive apparatus which he had adopted. The American journals frequently indulge in such a tone of bombast and exaggeration when describing any really ingenious inventions by our transatlantic brethren, that they must often be read with a certain discount, a drawback allowance for surplus enthusiasm. In the accounts of Professor Page's experiments, it is stated that a bar of iron, one hundred and sixty pounds weight, was made to spring up by magnetic action, and to move rapidly up and down, "dancing like a feather in the air, without any visible support." The distance thus moved, it is true, was only ten inches; but it was concluded, by a somewhat sweeping logic, that a hundred feet could be as readily gained as ten inches, and a ton raised as well as any smaller weight, by increasing the power. The mighty steam hammer, it was conjectured, would have to yield to this more powerful rival. Professor Page also exhibited an electro-magnetic engine of five-horse power, set in action by a galvanic battery occupying about three square feet; it was a reciprocating engine of two-feet stroke, and weighed (with the battery) about a ton. It was capable of working a circular saw ten inches in diameter, which cut up boards into laths, and which revolved eighty times in a minute while so doing. The inventor candidly avowed that, though the expense was less than that of steam in most engines, it was rather greater than in engines of cheap construction; but the newspaper commentators would not submit to any limitations to their bright predictions; for we are told that "we can now look forward with certainty to the time when coal will be put to better uses than to burn, scald, and destroy."

But although there is a tinge of extravagance in the published accounts of inventions and novelties, there is an energy across the Atlantic which is pretty sure to lead to something valuable. In the case now before us, the Congress appropriated 20,000 dollars to assist Professor Page in carrying on his experiments. Those experiments were made at Washington; and the object in view was to determine the availability of electric power as a substitute for steam power—not simply under a scientific aspect, but in the ordinary commercial arrangements of every-day life. The Professor has during the present year (1851) exhibited an electro-magnetic engine which works a cylinder printing-press. He has also made an electro-hammer, the head or mass of which weighs about fifty pounds, and which he causes to rise and fall with great rapidity and force. His next achievement was the construction of an electro-locomotive, with five-feet driving wheels and two-feet stroke, and a weight of more than ten tons; it was tried on the Baltimore Railway, and attained a speed of ten miles an hour on a level. In a letter to the *Scientific American* journal, the experimenter, in answer to certain objectors, drew attention to the memorable trial of locomotives on the Liverpool and Manchester Railway in 1829, and asserts that, even in its present state, he would venture to place his electro-locomotive as a competitor in a contest with such a steam-locomotive as the "Rocket" was twenty-two years ago. He moreover expresses a con-

fidence that his new contrivance "is capable of carrying two loaded passenger cars to Baltimore at the rate of twenty miles an hour, as soon as some of the very great and obvious defects are remedied."

One of the most recent projects in this curious department of mechanical enquiry, is Mr. Shepard's (or rather M. Nollet's, it having been patented for him in England) "Electro-magnetic heat, light, and motive-power producing machine." A long name this, and an imposing claim of power. The apparatus is very complex, and exhibits abundant ingenuity; it is formed on the theory of decomposing water by electric agency, and then developing light, and heat, and motive force, as consequences of the decomposition The merits of this new machine are now being put to the test in Belgium.

After all, the question of electro-mechanism seems likely to resolve itself into one of pounds, shillings, and pence. Will it pay?—is the query, here as elsewhere. Machinists tell us that they can move fly-wheels and drive locomotives by electricity; but machinists, with their account books before them, count up the cost, and look grave thereat. For every unit of power obtained, coal must be consumed in a steam-engine, and zinc in a battery; and the ratio between the production and the consumption must be determined in each case. Now the results of observation and calculation on this point have something very curious about them. Mr. Robert Hunt, in a paper read before the Society of Arts, in 1850, presented them in the following form:—He stated, that one grain of coal, consumed in the furnace of a Cornish mining steam-engine, generates power sufficient to lift one hundred and forty-three pounds one foot high; whereas, one grain of zinc, consumed in a galvanic battery, produces power adequate only to eighty pounds. Again, one cwt. of zinc costs twenty or thirty times as much as an equal weight of coal. Taking these and other facts into consideration, Mr. Hunt gave it as his opinion, that galvanic power is fifty times as costly as steam power. If this be correct, or if it approximate even remotely to correctness, it places the new rival to steam power in a very humble position; and it will have to submit with as good a grace as may be to a defeat.

### Electric Rivalry to Gas-Lighting.

There is another battle which electricity has carved out for itself, and on which it has not been less sanguine of victory—that of producing a light so brilliant and so steady, so cheap and so efficient, as to supersede gas.

It was in 1846 that the world was first startled with this novelty—the electric light. True it is, that scientific men had long been familiar with the intensity of the light caused by electric action, but it was Messrs. Greener and Staite, we believe, who first devised a form of apparatus for public lighting by such agency. Their patent of the year above named described an arrangement whereby small lumps of pure carbon, enclosed in air-tight vessels, were susceptible of being rendered luminous by currents of galvanic electricity. Little was done, in the first year, beyond the promulgation of the method; but in 1847 the evening gazers in London were astonished by the occasional flashes of intense light thrown out upon them from elevated spots; and one of the inventors estimated the merits of the system so highly, as to state the comparative cost of lighting to be in the ratio of one to six, or eight, as compared with gas. At one time it was the National Gallery, at another the north tower of Hungerford Bridge, at another the Duke of York's Column, at another the Polytechnic Institution, which was

thus made the theatre for the exhibition of these results; and, for a time, the "talk of the town" was this electric light and its marvels.

So far as it can be described in a few words, the following will convey an idea of the mode of producing the light. In the first place there were two small cylinders or bits of pure carbon, with their points placed some small fraction of an inch apart. As they were subjected to a slow combustion, the points of these cylinders receded further and further apart; but this recession was corrected by a train of wheel-work which advanced them in an equal degree in the opposite direction, so that the carbon points were maintained equidistant. A galvanic battery was provided, and the two carbon cylinders lay in the direction of the circuit through the wires, so that the galvanic circuit could not be completed unless the fluid could traverse the small distance from one piece of carbon to the other. It is one among the many properties of electricity, that when the subtle agent has thus to leap over the interval, as it were, from one point to another, it generates an intense heat at that point; and the points being, in the apparatus in question, formed of a slowly combustible body, like carbon, the heat generates, or is at least accompanied by, an intense light. The task which most called forth the ingenuity of the inventors, was to keep the carbon points at such a distance as to render the light continuous instead of intermitting; for an intermitting or flickering light would be nearly valueless in ordinary cases.

Numerous practical difficulties presented themselves in this novel experiment, and Mr. Staite obtained another patent in 1848, for their prospective removal. He devised a new form of galvanic battery, and new applications of exciting fluid to be used in it; he introduced a galvanometer, to measure the intensity of the current produced; he substituted the metal iridium for carbon at the points; he improved the means of maintaining a constant distance between the points; and he showed how so to arrange the apparatus, that the light may be made either continuous for ordinary purposes, or intermittent for lighthouses. The electric light was again exhibited in many public places; and in the same year another mode of producing the desired result was brought forward by MM. Achereau and Fourcault, at Paris.

In the following year, 1849, there was no lack of busy discussions in connection with this subject, or of suggestions for improved methods. M. Le Molt patented many modifications, especially in the form and arrangement of the charcoal points. Mr. Gillespie, in like manner, directed his attention to this very delicate part of the arrangement, on which so much depends, and suggested a new mode of maintaining the constant distance. Mr. Pearce was another of the inventors who took the carbon points into consideration, with a view to improve their mode of action. In the same year Mr. Staite, in conjunction with Mr. King, obtained another patent for a most extensive series of improvements, modifications, adaptations, extensions, or whatever they may best be termed, embracing almost every part of the subject, and showing significantly that the former method, however ingenious, must have been full of imperfections of one kind or other. Professor Grove, in a lecture at the Royal Institution, stated that he had illuminated the theatre of the London Institution by an electric light, five or six years previously; and he thought that much hope and promise were in store for us, in respect to a brilliant and economical principle of lighting. On the other hand, Mr. Rutter, who about that time wrote a treatise on gas lighting, gave the new-comer, the electric light, a few gentle rubs; and asked how it happened, if the light were so very efficient and economical, that it had not by that time come into use. Indeed,

there were many misgivings among scientific men as to the fitness of the electric agency for the object in view. Dr. Faraday, in a discussion on this question at the Birmingham Meeting of the British Association, commented on the irregular character of the electric light, and its inapplicability for purposes of general illumination: all objects appearing dark when the eye was embarrassed by the intensity of this extraordinary light.

A new claimant to public attention, Mr. Allman, brought out a new form of electric light in 1850, directed, as the greater number of the inventions have been, to the maintenance of proper distance between the points. He devised a very ingenious self-adjusting or regulating plan, whereby the distance should not always be the same, but should vary as the intensity of the current. When the flow is too energetic, and would consequently produce too bright a light, the points recede a little; whereas they approach more closely when the power becomes weak. The principle here involved is highly scientific, something like Watt's steam-engine governor; but it would require exact workmanship and careful handling to make it practically available.

The grand project, however, of 1850, so far as relates to this subject, was the American light, produced from water at no expense at all! It was announced that Mr. Paine, of Worcester, U.S., had discovered a mode of obtaining a brilliant light by the action of electricity on water, at a cost merely nominal. At first the world disbelieved it; but by dint of repeated assertions and assurances, the world (that is, the American world) began to think there must be something in the matter. The Boston newspapers took up the subject; and one of them stated in due form, that the inventor or discoverer has not only "extorted from nature the secret of the artificial production of light at a nominal cost, but that he has got hold of the key which unlocks and enables him to command a new force of nature, which is soon to supersede most of the forces now employed—something which is destined to work a revolution both in science and art." Brave words these: but electricity has had to hear and to bear much of this magniloquence. According to the description given in the Boston journals, there seem to have been a glass jar containing spirits of turpentine, another glass jar containing water, two flat strips of copper, a small tube which terminated in a jet or burner, and an electro-galvanic machine. When the machine was worked, water was decomposed; bubbles of gas escaped from the jar, and passed through the spirits of turpentine; and being then ignited, these bubbles yielded a brilliant light.

Such was the declaration, and on this declaration "issue was joined" by those who were not disposed to admit the philosophy of the explanation. Mr Paine is said to have devised a form of galvanic, or rather electro-magnetic machine, which, with the aid of two slips of copper, decomposes water, and liberates hydrogen; it is next said, that this hydrogen, by passing through spirits of turpentine, catches up in its transit a dose of carbon, or at least a new property which enables it to become a brilliant light-giving agent; and lastly it is affirmed, that this is done without any consumption of the turpentine. Many of the journalists proceeded at once to annihilate the customary theories of chemical action: they adduced Mr. Paine's experiments as proof that oxygen and hydrogen are not simple substances, that water contains no oxygen, and that hydrogen imbibes qualities from spirits of turpentine without occasioning any waste in it; and to add to the testimony, a Mr. Mathiot described at some length a mode which he adopted of passing hydrogen through turpentine to increase the brilliancy of the light produced from it, without occasioning any consumption or diminution of the turpentine so used.

A patent was taken out in London for this magical light; and the controversy concerning it was maintained on both sides of the Atlantic. Mr. Paine insisted that the usual theory concerning oxygen, hydrogen, and water is all wrong; that there is a particular gas which has not yet been isolated, and for which we have not yet a name; that this gas plus *positive* electricity constitutes oxygen; that the same gas plus *negative* electricity constitutes hydrogen; and that these two modifications of the same gas form water. Dr. Foster, of Evansville Medical College, in Indiana, conceived himself justified in saying that hydrogen is a metal in the state of vapour, just as steam is water in a state of vapour; and he formed a theory of the electric light on this basis. Another controversialist suggested that Mr. Paine should examine the components left in the battery after using, to see whether the existing atoms of oxygen (which he asserts never make their appearance at all) were to be found there. An English chemist of eminence repeated the experiment, and found that the turpentine *does* undergo consumption during the passage of the hydrogen through it; and that most of the inferences drawn from the proceeding are erroneous.

While this question was still under discussion, the engineering world was attracted by a patent obtained by Mr. Shepard, in which water is to be used as a store-house for powers quite marvellous. Water is to be decomposed by galvanism; the hydrogen is to take up a dose of carbon from another agent; the carburetted hydrogen thus produced is to yield a brilliant light; and it is to produce, in the act of burning, such an amount of caloric as to constitute an economic substitute for coal in furnaces of steam-boilers, &c. Such are the merits which the patent claims for the new method; and henceforward, the Shepard project shared with the Paine project the attention of those interested in such matters. Let the theories be what they may, the electro-magnetic apparatus of Mr. Paine, as described and diagrammed in the journals devoted to such subjects, is a fact, and a very complex fact, involving much delicate mechanism. Mr. Shepard's apparatus, too (or rather the apparatus of M. Nollet, patented for him by Mr. Shepard in England), was about the same time publicly described; but this relates to power-developing rather than to light-giving.

There certainly appears to be ground for thinking, that, whatever may be the success attained in future times, electro-mechanism and electro-lighting have not yet reached that position which is, to the busy world at large, the test of excellence—commercial advantageousness.

## Electro-Blasting.

The next industrial aspect under which electricity presents itself, is one concerning which there can be no doubt. Submarine blasting, and blasting at a distance from the operators, are certainly not the least curious among the industrial applications of electrical powers.

Colonel (now Major-General) Pasley was one of the first to employ this mighty agent in such a way. After the *Royal George*, whose fate at Spithead is so generally known, had been submerged for sixty years, this officer proposed a means of securing more of her stores than had yet been raised, and of removing the whole wreck piecemeal by blasting. Until that time only small articles had been recovered by divers, who descended in a diving bell. This plan was submitted to the Admiralty in 1839, and by them accepted.

Gutta percha was not then known, and Colonel Pasley was put to his wit's end to devise modes of protecting his wire and apparatus from the water. His wit, however, was equal to the task imposed upon it, for he fully succeeded. He had canisters constructed of a peculiar form, capable of containing 2000 lbs. to 3000 lbs. of gunpowder each. These he lowered from a boat, and fastened to the side of the wrecked vessel. He connected the canisters, by a sheathed copper wire, with a galvanic battery placed in a vessel at some distance; and after many abortive trials he fully attained the object in view. The galvanic current was conveyed along the wires to the canisters, where an explosion took place, and portions of the hull of the ill-fated ship were shattered at each explosion; light fragments and stores floated to the surface; while heavier articles were fished up with tackle managed by men who descended in diving dresses. Many explosions were made, and much of the sunken vessel was shattered and recovered; curiosity hunters were stored with fragments as relics of the *Royal George;* and the government recovered brass guns of sufficient value to pay for all Colonel Pasley's operations. Thus did a perfectly novel undertaking fully answer its intended purpose, both mechanically and financially.

Colonel Pasley having thus paved the way, other engineers were not slow to avail themselves of his experience in such matters. Captain Paris, an engineer at Boston, in the United States, adopted this method of electro-blasting, in 1840, to loosen large masses of rock. Excavations were made in a bed of rock, for the construction of quays and docks; and instead of using picks and similar tools, he employed gunpowder. The powder was used in various quantities, from four to sixteen ounces, enclosed in air-tight tin canisters. The copper wires from the battery were inserted in the canisters; and the wires and powder were well protected from the water by a thick composition. A hole was drilled in the rock for the reception of each canister, by a workman who descended in a diving bell; and when the canister was secured in the hole, and the requisite arrangements completed, an electric current exploded the gunpowder and blasted the rock. The engineer gave a highly eulogistic character to the new process, which he considers excels the old in presenting greater security from danger, greater certainty of action, greater expedition, greater explosive force with a given amount of powder, and less expense.

The mighty explosion near Shakspere's Cliff, at Dover, in 1843, will not be soon forgotten by those who were present on the occasion. The giant force of electricity, and the sagacious forethought of Mr. Cubitt, were both most fully illustrated on that occasion. During the progress of the bold sea-works for the South-Eastern Railway, between Dover and Folkestone, it was found that a jutting promontory, called Round Down Cliff, stood provokingly in the way of the line of rails; and the engineer proceeded to drive a tunnel through it. The soil proved treacherous, however, and the engineer thereupon resolved to sweep away the obstruction altogether. It must have required an unbounded faith in the efficacy of electro-blasting, for Mr. Cubitt to proceed as he did. He cut a horizontal gallery for a hundred yards through the cliff, from east to west; he made cross galleries from north to south; he sank deep shafts at the extremities of these cross galleries; he excavated chambers or small rooms at the bottoms of the shafts; and he deposited in these chambers the gunpowder which was to effect the. explosion. The quantity of powder thus used was large almost beyond belief; in the three chambers there was no less than 18,000 lbs. packed in bags enclosed in boxes. The

chambers were fifty or sixty feet inland from the face of the cliff. Behind the cliff, on the grass above, galvanic batteries were placed in a temporary building, and wires extended thence over the edge of the cliff to the chambers It was an eventful hour when this grand disruption took place. At two o'clock, on the 26th of January, three engineers worked three batteries at the same instant, three currents traversed three wires to the three chambers, and three explosions occurred at once. Never before was such a mass of solid rock removed by one engineering operation; a huge slice (so to speak) of the cliff was cut off in an instant, almost exactly in the direction which the engineer had wished; there was little noise, little smoke, few scattered fragments, but the whole mass descended to the sea with much less commotion than had been expected. Sir John Herschel was one of the spectators of this grand sight; and in a communication which he sent to the *Athenæum*, he spoke as follows:—"Of the noise accompanying the immediate explosion I can only describe it as a low murmur, lasting hardly more than half a second, and so faint, that had a companion at my elbow been speaking in an ordinary tone of voice, I doubt not it would have passed unheeded. Nor was the fall of the cliff (nearly 400 feet in height, and of which no less than 400,000 cubic yards were, within an interval of time hardly exceeding ten seconds, distributed over the beach on an area of eighteen acres, covered to an average depth of fourteen feet, and in many parts from thirty to fifty) accompanied with any considerable noise; certainly with none that attracted my own attention, or that of several others similarly stationed, with whom I afterwards compared notes."

All were satisfied, and rightly so, with this great experiment. The philosopher was satisfied to see electricity thus brought into useful operation; the engineer was satisfied, as it saved him six months' labour in cliff cutting; and the Company were satisfied, as it saved them 7000*l*. Three similar explosions were made during the same year, with smaller quantities of powder, to complete the cliff works near the same rugged spot. Railway travellers to and from Dover may easily catch a glimpse of the tolerably level chalk platform which has been formed with the débris of the disrupted Round Down Cliff.

Electro-blasting then became a recognised feature in engineering works. The rock of a quarry near Glasgow was successfully blasted by such means. A submarine rock in the North Esk was similarly blasted. Excavations were in like manner made in the harbour of Dunbar. Mr. Brunel employed the same agency in the cliff works of the South Devon Railway. The Wrekin, in Shropshire, has been electro-blasted for road material. The quarrying of rock near Queensferry in Scotland has been similarly effected. One of the most recent examples was the cliff-blasting at Seaford, effected in 1850, in connection with the new harbour works. In short, electricity has become one of the working instruments of the engineer: an instrument of mighty power, but requiring nice conduct for its guidance.

## Electric Difficulties: Lightning Conductors.

One of the relations in which electrical science stands to man is a peculiar one. It is not so much an example of "Industrial Applications of Electricity," as a mode of preventing electricity from *destroying* the works of human labour. Man here fights a battle against this redoubtable agent, rather than employs him as an assistant. We allude to the subject of *lightning rods*.

Terrible is the form in which electricity here presents itself. As developed in a galvanic battery, it can be adapted to our wants in a thousand ways; as developed in the clouds, it marks a path for itself with resistless power. When electric equilibrium is disturbed in the atmosphere, the surcharged quantity seeks a vent, and will take the shortest path or the best conductor which presents itself. If it meets with a metallic rod or wire, which is connected with the earth, it will travel quietly along that metal, and diffuse itself without injury; but if no such conductor presents itself, the result is startling. The electricity, the visual effects of which we designate *lightning*, seeks a pathway by which to descend to earth from its cloud dwelling; a rod of metal is the best railway for such a passenger; and trees, houses, and ships are rent asunder in the search for such a channel of conveyance.

Now it is the supplying of such an iron pathway which constitutes the philosophy of lightning conductors or thunder rods. Of the amount of destruction produced by lightning few persons have an adequate idea. Fuller gave a list of thirteen abbeys and monasteries which had been destroyed by lightning down to his time, about two centuries ago; and churches and houses are similarly destroyed or greatly injured every year. A calculation has been made (though we know not on what data) that buildings are thus destroyed in England to the value of £50,000 annually. But it is on the broad ocean that this giant destroyer most shows its power. The ships that have fallen a sacrifice are numerous almost beyond belief. In the British navy alone there are official records of more than two hundred and fifty ships of war which have been struck and injured by lightning since the year 1793, while merchantmen have been destroyed to an extent of which no exact estimate can be formed.

Pity, indeed, it seems, that there should be any laxity in the precautions taken to ward off this dreadful calamity. But such a laxity there has certainly been. It has required the incessant appeals and remonstrances of scientific men to obtain due attention to this subject. The first lightning rod is said to have been attached to a building by Dr. Watson, about ninety years ago. The practice spread into many countries, but very slowly. It is said, that when Guyton de Morveau put one up at Dijon, in 1776, he was violently attacked for his presumption by a superstitious mob; but that he appeased them by stating that the gilt point of the rod was sent by his holiness the Pope. It has gradually become established, that for any building to have a good lightning conductor, it is necessary that the metallie rod (copper is the best, but iron will suffice) should reach from the highest point of the building down in one unbroken line to the soil beneath: few buildings so provided have ever been injured by lightning; but if there is any want of continuity in the metal, the protection becomes doubtful and precarious.

In respect to ships, Dr. Watson, after a trial at his own house, recommended to the government that a copper chain should be furnished to every ship, to be suspended from the mast head, and to hang over the side of the ship into the sea. The plan was adopted, but after a strange fashion; the chain was made, and a box provided to keep it in, from whence it was to be removed for use "as occasion requires." But lightning flashes are wont to do their own work at their own time, without giving formal notice to the captains of the royal ships; and it often happened that an unfortunate vessel received a shattering stroke before the protector could be removed from its box. It was found, too, that the chain form is not efficient for conduction, and that not only one, but all the masts ought to be protected. Thirty years ago Mr. Snow Harris (who has

since been knighted for his services on this important subject) brought before the Admiralty a plan for improved lightning conductors for the Royal Navy; he fought the battle perseveringly, year after year, against one administration after another, until at length conviction was forced upon official minds, which receive conviction rather slowly, and his method is coming every year more and more into use. It is simply as follows:—Each mast is made in effect a lightning conductor, by two bands of copper inserted in its surface, and extending from top to bottom; the bands are strong enough and elastic enough to accommodate themselves to the strains to which the mast is exposed. The copper bands extend under the deck beams to the side of the vessel, and from the mast to the large metal bolts of the keel and keelson; so that the metal of the vessel itself is made to form part of the general system of conduction. So far as recorded evidence extends, the national saving effected through the protective uses of these conductors must have been immense.

## Electricity in the Workshop.

But we may leave these terrible examples of electric power, and of the means adopted to ward them off, and resume our glance at those more peaceful operations in which this wonderful agent is employed as a handmaid to the arts of civilization.

"Electricity in the workshop" may sound a strange phrase; but it is a correct and fitting one. Electricity *does* appear in the workshop, and is there employed as an actual worker; and, moreover, it performs manufacturing operations which would baffle the skill of the most talented artizans. Franklin gained celebrity for having gently drawn down lightning from above by the string of a kite; but it was left for later times to tame this rough agent (or at least its congener, electricity) and make it a metal-worker in Birmingham factories.

In this, as in other departments of electro-chemical action, it is difficult to say to whom the honour is due of the first practical application; it can only be settled approximately. Professor Jacobi of St. Petersburgh, Mr. Spencer of Liverpool, and Mr. Jordan of London, appear to have claims to share the honour among them. But this is a nice point, on which we will not venture to dwell. Suffice it to say that, about twelve or fourteen years ago, metal was rendered obtainable from the liquid in a galvanic battery, by peculiar arrangements. Let those who have been familiar with the admirable Typographical Section, in the Austrian department of the Great Exhibition, consider that the large and beautiful sheet of copper there displayed, more than thirty feet in length, was produced from a cold salt liquid: they will thus gain a little insight into the marvels of this process. Stripped as much as possible of scientific difficulties, and presented in its simplest form, this transformation may be thus elucidated. Diluted sulphuric acid is poured into a porous vessel; this is placed in a larger vessel containing a solution of sulphate of copper; a piece of zinc is placed in the former, and a piece of silver or of copper in the latter, and both pieces are connected by a wire. Then does the wondrous agent, electricity, begin its work; a current sets in from the zinc to the acid, thence through the porous vessel to the sulphate, thence to the silver or copper, and thence to the conducting wire back again to the zinc; and so on in an endless circuit. But electricity never makes such a circuit without disturbing the chemical relations of the bodies through which it passes: the zinc, the silver or copper, the sulphuric acid, the oxygen, and the hydrogen—all are so far

affected that the zinc becomes eaten away, while a beautiful deposit of metallic copper, derived from the decomposition of the sulphate, appears on the surface of the silver or copper. This bit of philosophy must suffice for our present purpose.

Now the Birmingham manufacturers, ever alive (as manufacturers are wont to be) to any improvements which may advance their trade, saw that there was a principle of great commercial value here developed. Copper is not the only metal which can be thus precipitated; gold, silver, platinum, and other metals may be similarly treated; and it was conceived that a thin layer of gold or silver might be applied to the surface of cheaper metals by this process, instead of by the older process of "plating." Let the brilliant display of Messrs. Elkington, at the Crystal Palace, tell how great has been the success attained in this new art. Let us compare the real plate with the electro-plate, and then appreciate the striking peculiarities of a process which enables so beautiful a silvery surface, so close an imitation of solid silver, to be produced from the liquid solution in a galvanic battery.

How is an electro-silver vase, or candelabrum, or table ornament, or honorary trophy produced? The answer is full of interest. There is first the artist, the tasteful designer, employed; he exercises all the talent which he may have acquired by nature and education, to produce a design which shall combine fitness of adaptation with grace of form, and decoration. Next comes the modeller: he places before him the design which has been laid down on paper, and proceeds to build up a realization of that design: he works upon a mass of smooth wax, which, by the aid of variously-shaped tools in wood and bone, he fashions into an exact representation of the article to be produced. To the modeller succeeds the moulder, who makes a mould in lead or some other fusible metal; this would, of course, present a reverse to the model—hollows instead of projections, and projections instead of hollows. Next to the modeller comes the pattern-maker, who, by a similar process of casting, makes a cast in brass from the lead mould; this brass pattern is carefully touched up and finished, and constitutes a more perfected edition of the wax model; and it serves as the type, as it were, of all the articles to be produced. Again and again does the casting proceed; for as there was a lead mould made from the wax model, so is there now a sand mould made from the brass pattern; and as this brass pattern was obtained from the lead mould, so, lastly, is there a white metal cast made from the sand mould. The white metal cast is the article to be produced and sold, though it has not yet received its silvery garment. The luxuriant ornament which we are here supposing to be under formation, may require other preparatory processes; it may have decorative details in thin metal, which require stamping; it may need the addition of thin pieces, made from sheets by brazing or hammering; or it may render necessary the soldering of many pieces together. But we will leap over these intermediate processes, and suppose the article to be completely formed, in a white metal, composed of zinc, copper, and nickel. It is dipped into a tank containing a chemical solution of silver, in which also a few sheets of pure silver are immersed. Then comes the mysterious agency of electro-chemistry. The vase or other article being placed in connection with the wires of a battery, a current is generated, the solution is decomposed, the atoms of silver leave it and cling to the vase, other atoms of silver leave the plates to re-invigorate the solution, and so the chain of operations proceeds, until the vase is coated with pure silver, atom by atom. These atoms cling together; and ac-

cording to the intensity of the current, the strength of the solution, and the time of immersion, does the deposited coat become thicker.

It is thus that the silvery coat of electro-plate is produced: the subsequent burnishing and finishing we need not dwell on here. And thus might a thin coating of gold, or copper, or iron, or zinc, or platinum, be applied to any other metal, by changing the nature of the chemical solution in the tank. And thus also might the delicate coating be applied to a non-metallic body beneath, by an intervening preparation of black lead or of phosphorus. And thus, again, might fruits and flowers, stems and leaves, wings and feathers, be coated with metal with the same ease as any manufactured articles. Not only may substances of almost every kind be thus coated, but the entire thickness of an article in metal may be thus made by electro-deposit: all that is required is, that provision should be made to ensure the non-adhesion of the deposited metal on the framework or mould.

When we see large sheets of copper produced in this wonderful manner, we have proof that the metal, precipitated atom by atom from the solution, unites into its proper metallic homogeneous state; and this has given a range of applicability of the method to useful and ornamental purposes, quite beyond present calculation. Sometimes we meet with articles of table-plate so produced; sometimes buttons, pens, trinkets, or cheap jewellery; sometimes it presents itself as a coating for chronometer springs and for magnetic needles; sometimes as a mode of preserving medallions by a minute layer of copper; sometimes as a mode of permanently retaining the forms of vegetable objects, by encasing them in gold, silver, or copper envelopes; or even as a preservative for insects, for details so minute as those of a butterfly's wings may be preserved by the electro deposit; sometimes as a covering for basket-work, or for lace. The suggestions for new modes of useful applications are not less numerous than the applications themselves. One proposal is for a mode of taking impressions in copper from ornamental brasses by electro deposit. Another is for making stamps and dies by electro deposit on embossed surfaces. Another is for obtaining copies of graduated instruments from a carefully prepared standard. Another is for making tools for grinding specula and lenses, by depositing the thin film on the curved surface of the very article to be polished; nay, more, the specula themselves have in some cases been made by electro deposit. A proposal of much greater magnitude, in respect to its influence on manufactures, is that of smelting by electricity; this is not so much an example of electro deposit as of electro separation; its theoretical soundness is undisputed, and small portions of ore have actually been smelted by this agency; but up to the present time the system has not yet entered the domain of practical manufactures.

Electric action is now at the threshold of many manufacturing processes, besides that of smelting, just alluded to. It is waiting for admission, and well be admitted step by step. Copper tubes and pipes have been made by electro deposit; and we may yet see the day when they will thus be made with commercial advantage. Calico-printing has been effected also by this agency, in a curious manner. Two rollers are prepared, one of plain iron, and one on which a pattern has been formed by pieces of various kinds of metal inserted in the surface. The calico dips into a liquid having peculiar chemical relations to the various metals; and while it passes between the rollers, a galvanic current is allowed to form a circuit through

the apparatus. The singular result is, that different colours are produced on the calico by the difference in the action between the various metals and the liquid with which it is saturated.

A glance will presently be taken at the curiosities which electricity presents when connected with fine-art printing; but it may here be stated, that ordinary letter-press printing is beginning to receive aid from the same wonderful agent. A method has been devised for covering the surface of ordinary type with a film of copper, by electro-deposit: copper is known to be ten or twelve times as tenacious as lead; but as it is difficult to melt, and is much more costly, copper types are almost unknown; and, therefore, an attempt is now being made to combine the tenacity of the one with the cheapness and fusibility of the other, by facing ordinary type with copper. Dr. Newton, in a paper recently read before the Franklin Institute at Philadelphia, states that, in a widely-spread religious publication at New York, ordinary types are nearly worn out by 170,000 impressions, while the galvanized type is little injured by six times this number; that the new types require less ink, and waste less than ordinary type; that the copper face can be read better by the compositor than the leaden face; that the two metals can easily be separated for remelting, the one melting at 500° and the other at 1800° Fahrenheit; and that the increased expense is not more than 30 per cent. Whether English printers will confirm this favourable American verdict, time must show.

A very pretty specimen of electro-metallurgy is presented in Mr. James's elaborate model of the Britannia Bridge, which has had some million pairs of eyes upon it at the Industrial Exhibition. The two great tubes of this tubular bridge are of course the most notable parts of the structure; and Mr. James has made his mimic tubes in the model entirely by the electro process.

### Electricity in Relation to the Fine Arts.

But if electro-chemical action thus lends a kindly hand to the manufacturing arts, not less marked are its services to the fine arts, or those where beauty and grace prevail over mere material use.

The copying of an exquisite line engraving, from a copper or steel plate to an electro-copper deposit, although now become a very familiar process, is really a wonderful one; for let the lines of the engraving be as fine and minute as they may, the deposited atoms of copper mark them all distinctly—so infinitely small is each atom or particle compared with any magnitude which human hands can produce. Like many other wonderful and beautiful processes, this is a very simple one. Let us suppose that a large steel or copper engraving is to be so copied. The plate is immersed in a chemical solution of copper, and a thick film is precipitated on it by electro deposit. This film may be easily loosened from the plate, and its surface then presents a reverse to the plate, protuberances instead of engraved lines, and cavities instead of plain or raised portions. The film is employed as a sort of mould; for it is, in its turn, immersed in the solution, and made the basis for a second deposition. This second deposition is allowed to continue until a plate as thick as the original is produced; and this plate, when separated from its parent film, is seen to be an exact counterpart of the engraved plate first operated upon. So perfect is the resemblance, that, if the electro-plate be made with care, an inked impression printed from it can be detected from

one printed from the original plate only by an experienced judge: to ordinary eyes they are equal in all respects.

The first attempts at electrography (as this art is sometimes called) were in producing impressions from coins, medals, dies, seals, cameos, intaglios, and such like small articles in bas-relief; and these have always been regarded as among the neatest and prettiest manifestations of this curious art. But it is becoming wider and wider in its application. Not only does it produce copies from engraved plates, but even the plates themselves have been thus made by electro-coppering, for the engraver to work upon. In Mr. Smee's treatise on *Electro-Metallurgy* he gives three engravings of a very instructive kind, to show how a method of stereotyping might be practised by electro deposit. They were produced in three different ways. In the first, a device was engraved on a wood block; a copper reverse from this was taken by electro deposit; a cast was taken from this in soft or fusible metal; and impressions were printed from this cast. In the second, the device was engraved on wood; a reverse was taken from the wood in fusible metal; a copper plate was deposited on the metal by the electro process; and the printing was effected from the copper. In the third, the device was engraved on wood; a mould from this was taken in plaster; an electro cast was taken from the plaster; and the impressions were obtained from this copper deposit. The impressions vary somewhat in fineness; but all suffice to show that the electro process may fittingly form one part of the series.

There are now to be seen, in fine-art exhibitions and elsewhere, copper busts which illustrate the electrotype art in a very remarkable way. The Great Exhibition has displayed to us a few of colossal dimensions, besides numerous smaller specimens. These consist wholly of copper, in a thin sheet; and the whole of the metal has been reduced or precipitated from a liquid solution. We believe that the first example of this striking production was a bust of the late Dr. Dalton, made by Mr. Cheverton about ten years ago; and the practicability being thus demonstrated, the art may be now followed to any extent. The processes are curious. The bust is first modelled in some kind of clay, which may afterwards easily be broken away piecemeal; and on this a thick copper film is deposited by the electro process. The clay core or model being broken away, the copper remains as a hollow shell, the inside of which has taken the exact impress (though reversed) of the outside of the bust. This copper shell, on being properly prepared on the inner surface, is made the groundwork on which a second deposition takes place; it is used, in fact, as a mould, from which one or more busts may be procured. We might even imagine a nest of busts, one within another, each serving as a mould for the one within it; and thus we might form a goodly family of Napoleons, or Byrons, or Scotts, graduating from the colossal to the petite; the number of the series depending on the thickness of the metal deposited to form each of them. Such a series would certainly be a "curiosity" of electrotyping; but it would require some mechanical tact to effect the liberation of each bust from its enveloping mould.

Architects and sculptors are gradually availing themselves of this art in the furtherance of their professional labours. The late Bavarian sculptor, Stiglmayer, who was employed by King Ludwig on so many important works at Munich, devised a mode of coating colossal plaster statues with copper, by the electro process, in a remarkably expeditious way. But one of the most important applications of the art is that which is exhibited in the new and splendid cathedral of St. Isaac, at St. Petersburgh, on which the Emperor has expended

large sums. Certain parts have been ornamented in a remarkable way. The cathedral has seven very large doors, or rather door-ways, three of which are forty-four feet wide by thirty high; they are formed of bronze, but all the adornments are produced by the electro process. These adornments are of a most elaborate nature; they comprise no less than fifty-one bas-reliefs, sixty-three statues, and eighty-four alto-relievo busts. It is not simply as a matter of economy that the electro process has been adopted; for the Czar is not a man to entertain scruples on such a point; but there are certain advantages of an artistic character. By the electro process the sculptor is sure to have his model faithfully copied; and the lightness of the material enables him to impart bolder relief to his designs than if they were cast in bronze; while this lightness of weight also justifies him in suspending pendants or bosses from vaulting, of a larger size than would be safe if made in any other way. Among our own English productions, Messrs. Elkington have produced an electro statue of the Duke of Gloucester, for the new House of Lords. The same successful firm produced, by the electro process, the gold and silver decorations of Her Majesty's jewel casket, which has adorned the main avenue of the Crystal Palace.

It has been sometimes apprehended that the startling discoveries of the last few years will tend to lower the tone of art in its purer acceptation; that if Light becomes an artist, by producing photographic pictures, and Electricity an artist, by producing electrographs, the man of genius may be superseded altogether. But this is a mistake, arising from too humble an estimate of art. A photograph is a *copy*, and nothing but a copy; so is an electrograph; neither can originate, or combine, or modify, or idealize. If a faithful copy of forms or colours be required, one or other of these arts can present it; but if something more than a mere copy be wanted, the *mind* of the artist is as necessary now as before these arts were known; and such it will continue to be. Photography and electrography will expedite and assist the lower departments of art, but they will never supersede the higher.

These remarks are suggested by the truly interesting etchings recently produced by electricity. Some persons have hastily assumed that the etcher's "occupation 's gone" as soon as the chemist's laboratory becomes the artist's studio. But, by looking a little farther into the matter, it will be seen that the mind of an artist is as much required in producing the design on a plate in the one process as in the other: it is not science as opposed to art, but electricity as opposed to aquafortis. Let us illustrate this. In etching, a plate is coated with a peculiar composition; and the etcher, with sharp instruments, scrapes away the composition in all the parts which are to form the design; the copper in these exposed lines and spots is then eaten away by the corroding action of aquafortis on the old process; while on the new it is removed by the action of the galvanic battery. The battery is so adjusted that the copper, instead of being deposited on the plate from another body, leaves the plate and deposits itself on that body.

But the method of *electrotint* is more curious, inasmuch as there is no etching at all. A plate of white metal, presenting a dull white surface, is prepared; and on this the artist paints his design in full, giving every touch which is required in his picture; he uses a pigment mixed expressly for this purpose, without regard to colour; and he applies it with brushes, pencils, and small pointed pieces of wood or bone. He proceeds on the same principle as the copper-plate engraver and the etcher in this respect—that all the parts which are to be *white* in the impression are left untouched by the paint.

Different depths of light and shade are managed by different thicknesses of the paint laid on; and it requires much artistic skill to effect this. The picture being thus far finished and dried, the plate is exposed to the electro process; a film or sheet of copper is formed on it, in which the slight alterna tions of ridges and hollows are faithfully copied, but reversed; and the plate thus formed is capable of being worked at the copper-plate press in the ordinary way. By modifying the details, this process is made to imitate wood engraving rather than etching. In a wood engraving, unlike etching, the parts which are to be *black* are left untouched by the engraver, or left prominent; and, in like manner, the electrotinter gives prominence to the lines which are to give a black impression, by reversing the process before described. His pencilling must be peculiar, for he avoids touching with paint those lines which are really to constitute his design. When the painting is finished, an electrotype plate from it will be suitable for surface printing at the common press. These remarkable processes were introduced by Mr. Palmer eight or ten years ago; and in the Austrian department at the Great Exhibition we have had an opportunity of seeing a production which, if not identical, is certainly of analogous character. There is, in the instance in question, a white metal plate, on which a picture is painted in a dark-coloured pigment; by the side of this is a copper plate, produced from the former by electro deposit; and by the side of this again is a proof impression of the engraving so obtained; and the excellence of the print thus produced, without any process of engraving or etching whatever, shows that this singular method may become applicable to varied purposes.

The variations of these processes are now becoming numerous. It is said by Mr. Smee, in a recent edition of his work on Electro-Metallurgy, that the title-page of *Punch*, and the vignette at the top of the *Illustrated London News*, are both printed from copper electrographs; and that several millions of impressions have been obtained from different coppers, all derived originally from the same woodcut. In such cases a cast is taken from the woodcut, an electrotype is produced from the cast, and the impression is printed from the electrotype. In a recent number of the *Illustrated News* the proprietors stated that they have long been of opinion that something different from wood-block engravings will by-and-by be available for surface-printing; that they are watching with anxious interest the progress of electrography in this direction; but that they have not, up to the present time, felt justified in adopting the method extensively until further improvements are made. *Glyphography*, or the electro-etching of plates, has been found well fitted for maps; there is a gazetteer now in course of publication, the maps of which form excellent specimens of Glyphography. It is also a notable circumstance, that the Ordnance maps are printed from electrotype plates; a series of them, with some of the plates in juxtaposition, have been displayed at the Great Exhibition. But perhaps the most curious of all these curiosities is the union of photography with electrography. Most readers know that the effects produced in the first of these arts is due to the action of light on a carefully-prepared and very sensitive surface. Now it has been found that varied intensities of light produce varied intensities of chemical action in the metal plate employed, and that the galvanic action will then eat away the copper to varied depths; thus producing a plate with the alternate depths of lines fitted for printing. Light is, in this case, the painter, and electricity the engraver, of a picture,

# GOLD: IN THE MINE, THE MINT, AND THE WORKSHOP.

In September, 1847, one Captain Suter or Sutter was a bold, prosperous, enterprising, intelligent settler in Upper California. He was a Swiss by birth; he had served Charles X. as one of the Swiss Guard at the Tuileries; he emigrated to Missouri after the Bourbon revolution of 1830; he removed thence to the Oregon territory in 1836; he made a farther advance in 1839 to California, where he built a fort named New Helvetia on the river Sacramento; he gradually accumulated around him 4000 oxen, 1500 horses and mules, 2000 sheep, a vast acreage of land under grain crops, and two trading vessels in the river; he had his fort supplied with twelve pieces of artillery, and defended by a garrison of seventy men; and he was thus, in all probability, the wealthiest and most influential man beyond the Rocky Mountains. The month above named was an important one to this bold captain, and to the world at large. He contracted with a Mr. Marshall to construct a saw-mill near a pine forest. The supply of water to this mill was so situated as to wash down much mud and gravel from the higher course of the stream; and Mr. Marshall, watching the progress of his works one day, saw some glittering particles in this mud. He formed his own conclusions of the nature of these shining morsels; and having shown some of them to the Captain, it was agreed to keep the matter a secret for a time. Such secrets, however, do not keep; they *will* not keep: it was soon noised abroad that GOLD had been discovered at the American Fork of the Sacramento, and a gold fever thereupon sprang up. A few labourers collected some of the gold-dust, and took it for sale to San Francisco, at which town the Sacramento enters the Pacific; hundreds flocked up the river; Indians were hired, soldiers and sailors deserted, shopkeepers closed their shops, and San Francisco became almost abandoned. Two men, employing a hundred Indians, got 17,000 dollars' worth of gold in a short time; another party, 12,000; and another, 16,000. In two or three months, one store-keeper at Suter's Fort sold goods for 36,000 dollars' worth of gold-dust.

Such was the opening scene of the Californian drama, which has since set the whole world in commotion. It is to this gold, and to gold generally—its obtainment and its application, its uses and its "curiosities"—that the present sheet will be devoted.

### The Gold Mines of Past Ages.

The world has never known a period (within historic limits, at least) when gold was not cherished and valued highly. Whether it is because this beautiful metal presents a brilliant colour and lustre, or because it is little affected

by external agents, or because it is easily wrought into useful and ornamental forms, the evidence is clear enough that gold has had a widely-spread and a long-continued reign. We are told of an age of iron, and an age of bronze, and of the golden ages, *par excellence;* and these metaphors are founded on certain characteristics of certain periods in history; but, in one sense, the golden age never dies, if we judge from the estimation in which this one metal is held. Whether a country possessing iron mines is not richer than one which boasts of its gold, is quite another question, which must be discussed on a much wider basis.

As different centuries in past history have exhibited differences in the supply of gold, so does the geographical distribution differ greatly. All the four quarters of the world (what to designate Australia is now a puzzle: a "fifth quarter" not being quite orthodox) contain gold mines, though in very unequal degree. For a considerable number of years before the discovery of the mines of California, the world was chiefly supplied with gold from Siberia and the Indian islands in Asia, from Hungary and Transylvania in Europe, from a few scattered places in Africa, from Brazil in South America, and from Carolina in North America. Taking the average of many years before 1847, the annual produce was supposed to be about 80,000 lbs., having a money value of somewhat less than £5,000,000.

Many have been the eager hopes and anticipations that our own little island may be a golden land. It is certain that the Irish of early times had abundance of gold ornaments, the material for which seems to have been derived from their own "green isle." But there is now very little reason to expect that the age of gold will supersede the age of iron, so far as regards the mineral wealth of the British Isles. There are traces of gold in Ireland, in Wales, at Leadhills, at Glen Turret, at Cumberhead near Lanark, and in other places; sometimes they occur in quartz veins, sometimes in alluvial deposits.

The most notable attempt yet made in this department of mining among us has been in Wicklow. On the boundary line between Wicklow and Wexford counties is a mountain called Croghan Kinshela: many streams descend from this mountain, and in the muddy bed of these streams gold was discovered about half a century ago. It was not merely fragmentary morsels which thus presented themselves, but the eye of the gold-seeker was tempted by pieces or lumps up to twenty-two ounces weight. The gold was accompanied by other metals, and was generally found several feet below the surface. This discovery made, we may be sure, no little stir at the time. One of the stories connected with the subject tells how an old schoolmaster, about the year 1770, was wont to talk about the riches of the district; how he wandered out at night, until his neighbours thought he was a little touched in his intellect; how he married a young wife, and communicated the secret to her; how she gossiped about it to her neighbours; and how the good news thereupon spread. But the matter was not seriously taken up till 1796, when a man, while crossing a valley-brook, picked up a glittering fragment which proved to be nearly half an ounce of gold, at least as pure as that of standard coin. The news got wind; young and old, male and female, hale and infirm —all hied to the valleys, and groped about for the precious treasure; it was not a hoax nor a day dream, for the peasants gathered several thousand pounds' worth in two months. It was at once thought that a bright day had arisen for poor old Ireland; that she had the means of (golden) regeneration within herself; but alas, the hopes were "too bright to last." The Govern-

ment took the subject in hand, and appointed a Mr. Weaver to superintend the operations. He instituted a search into the various modes in which the gold had deposited itself, with a view to establish a systematic mode of extraction; he engaged diggers and collectors and labourers; and he established the necessary commercial machinery for carrying on operations. It was calculated that the country people had collected £10,000 worth of gold before the Government had taken possession of the works; and the Government collected 945 ounces, valued at £3675; but when the accounts came to be balanced, it was found that the expenses had exceeded the receipts. The bright vision was dissipated, the scheme was abandoned, and the Government has never since taken part in the matter. The Wicklow gold mines have still an interest to the minds of some, but the golden particles are too "few and far between" to render the collection a very profitable employment.

Quitting our own islands, and directing a glance to the continent of Europe, we find that Hungary and Transylvania are among the chief gold countries; the precious metal being found in the sands of some of the rivers. There are also two or three Bohemian rivers which yield a small supply. In one part of the valley of the Rhine, between Mannheim and Basle, gold is found in a sand-bank in the river, but not in sufficient quantity for working. There are many parts of Europe whence gold was once obtainable in profitable quantity, but where the search is now abandoned: such are the banks of the Ebro, the Rhone, and the Danube. Africa is said to yield about 5000 lbs. weight of gold annually—from the district between Abyssinia and Darfur; from the region south of the Great Sahara; from the Mozambique coast; from the sands of the Gambia, the Senegal, and the Niger; and from that portion of the Atlantic sea-board which obtains the name of Gold Coast. Asia contributes small supplies from some of the rivers in Asia Minor, from the Indian islands, and from certain parts of India, China, Cochin-China, and Sumatra.

But of all the contributions which the Old World produces, in this department of mineral wealth, none equal those of the vast Russian Empire. The quantity has been rapidly increasing within the last few years. In 1842 the quantity was about 33,000 lbs., and this has since risen to 50,000, 60,000, and even 80,000 lbs. There are two groups of Russian gold deposits, near the Ural and the Altai Mountains respectively. The eastern group, near the Altai, is said to comprise a district as large as France, over the whole area of which "not only are considerable quantities of gold found mingled with sand and gravel on the surface, but even the rocks themselves, when pounded up, are found to afford a percentage of that valuable metal."

It is curious to observe how varied are the aspects in which the gold presents itself. In the Ural district, for instance, it occurs in minute fragments imbedded in coarse gravel, somewhat like that at Woolwich; it also occurs disseminated in veins of quartz in hard rocks, which are worked by regular subterranean mining operations; and it occurs associated with platinum, and one or two other rare metals, in detached fragments of rock. The processes adopted by the gold collectors vary according to these varied modes of deposit. If the sand of any river contains a few grains of gold to five pounds weight of sand; it will pay for the expense of gold-washing. In the Altai district the gold appears disseminated in a quartz sand, not merely in river valleys, but sometimes even to the summit of a mountain. There has been one mass obtained, weighing no less than 78 lbs., and valued at £3000.

Crossing the Atlantic, we find that Brazil, until the recent discoveries in California, has been the richest of American gold countries. There is a chain

of mountains running parallel with the coast, some distance inland; and in the rivers which flow from these mountains, gold is found in considerable quantity. There is much hard rock in the river valleys: in this rock is a stratum of gravel and rounded pebbles, and in this stratum the gold is met with. In the province of Minas Geraes, gold occurs also in veins in the hard rock, and mining operations have recently commenced there. The Brazilian produce gradually rose in annual amount till 1753; it maintained a very high position till 1763, but since that time it has been declining. This decline is attributable to the exhaustion of the auriferous sands; the gold veins in hard rock have only recently begun to be mined, owing to the want of capital.

Other districts of America yield small portions of the precious metal. In Mexico the silver (which forms the chief wealth of the country) frequently contains gold, but not often in sufficient quantity to pay for the separation; there are also a few veins in the rocks. In Peru and in New Granada there are gold veins and washings in small quantity. In Central America there are washings which have become nearly exhausted. The Appalachian chain in North America gives rise to many rivers which flow into the Atlantic; and in the sands of a few of these rivers (chiefly in Virginia, Carolina, and Georgia) gold occurs in sufficient quantity to pay for working; the whole are said to yield about 3000 lbs. of gold annually, and there has been known to occur a mass weighing 28 lbs.

But the north of the American continent is "looking up," as gold speculators would say. Not only has California (of which more presently) suddenly acquired a golden reputation, but Canada, our own British Canada, has made a humble start in the same line of wealth. Within the last year or two, gold has been found in that colony; and no sooner was this discovery announced, than adventurers were found to flock thither, as they probably would to Spitzbergen, or even to the North Pole, if they were told that gold existed there. The latest accounts from Canada state that five hundred Americans have, during the summer of 1851, been roaming on the banks of a river in Lower Canada, where a little gold had been before found; and that others from New Brunswick were also in the same field of enterprise. Their success, however, has not been very encouraging. Still, as it is known that indications of gold have appeared over three thousand square miles of country in Lower Canada, there is quite sufficient to whet the appetite of gold-seekers. The gold is found in the beds of the streams, and in small pieces with quartz attached; but no auriferous vein of quartz has been yet found.

### California and its Treasures.

The wonders of California are, however, those which most press for notice; excepting, perhaps, the still more recent outburst in Australia.

If we look at a modern map of California, such as that which accompanies Mr. Bryant's Narrative, we see a very tempting yellow patch between the Rocky Mountains and the Pacific. If that patch is not real gold, it is at least intended to symbolise gold; for it marks the limits within which gold has been obtained. Between the Rocky Mountains and the ocean there is another mountain ridge, parallel with the coast; there is thus formed an oblong basin or valley between the two ranges, nearly north and south; and for a distance of nearly 600 miles (35° to 42° N. lat.), the rivers of this valley have no outlet whatever except at San Francisco, where a gap occurs in the coast ridge. It is thus that nature has made San Francisco an important place, independent

of the gold question. This harbour (one of the finest in the world) is about in latitude 38°; the Sacramento flows southward along the basin or valley to this point; while the San Joaquim flows northward to the same meeting place —the two rivers having numerous tributaries which drain the Rocky Mountain region. The San Joaquim and its feeders have been found to yield gold, to a point about one degree south of San Francisco; but the Sacramento and its tributaries, north of the harbour, form the gold region proper. Here we find the American River, Bear River, Yubah River, Feather River, Butte River, Antelope Creek, Mill Creek, Deer Creek, Chico Creek—all flowing into the Sacramento, and all yielding precious returns to the gold-seekers.

Such is the region whither emigrants have for four years been wandering. It is remarkable that the political relations between the United States and Mexico had shortly before given Upper California to the former nation; and that other negotiations with England had given to the latter a more restricted possession of territory on the Pacific coast than had before been claimed; so that the United States, by these two political causes, and by the Californian discoveries, became suddenly possessed of gold mines, which she is earnestly endeavouring to bring under the operation of a system.

Would we know how *El Dorado* presents itself to the view of an overland traveller to California, we may take Mr. Kelly's recent 'Excursion to California,' as an informant. This gold-seeker left Liverpool per steamer, landed at New York, travelled by rail to Albany on the Hudson, thence by rail to Buffalo on Lake Erie, crossed Upper Canada by coach to Detroit, thence by rail and by waggon to the southern point of Lake Michigan, then on by steam conveyance through a canal to the Illinois and Mississippi Rivers. Arrived at St. Louis, the "Queen of the West," he steamed four hundred miles up the Missouri to Independence; and then, with a large party, made a waggon journey of two thousand miles to the gold region—over wide prairies, rapid rivers, rugged crags, snowy peaks, through the Mormon settlement at the Great Salt Lake, and through perils enough to wear the heart out of any but a determined man. After these two thousand miles of waggon travelling, which occupied a hundred and two days, the weary adventurers suddenly "encountered some Chilians on the banks of a little stream, all but dried up, looking for what we came thousands of miles in quest of. It is scarcely necessary to state that we halted to noon (the "noon" is the mid-day rest in those regions) in their neighbourhood, to have our long day-dream interpreted, and see with mortal eyes the process of picking and washing gold from the common clay. The operations just there happened to be on a limited scale; nevertheless, little as it was, it appeared marvellous to us to see pailsful of mud and dirt gathered, and, after a very short and simple species of washing, to find in the bottom of the basins a deposit of the veritable stuff itself; after which the doubts and fears, which, like the misty vapours of a summer's morning, hovered and floated over our brilliant expectations, rolled away and vanished as the golden sun became revealed. It was now no longer an exaggerated fiction about the treasures of California." A few miles onward they came to some "dry diggings," where miners dig in the dry soil, picking out particles of gold from amongst the clay without the agency of water. "Of course it must be plentiful, and in good sized grains, when the eye can detect them mixed with the red clay; and much that is in mere dust must necessarily escape in the first instance; but in the wet season many of them (the diggers) wash the heaps over that they had dry-picked before, and with very great success. I sat for half an hour by the side of a digger, watching how he

worked, during which he frequently pointed out particles in the earth before he picked them out that would certainly escape an unpractised eye. He admitted he averaged one and a half ounce per day, working only about six hours." This spot was about forty miles from Sacramento city, and nearly two hundred from San Francisco.

The account which Colonel Mason, an officer dispatched by the United States government to report on the capabilities of California, gives of a scene which met his view, will fittingly illustrate the earlier operations of gold finding in that land of promise:—"The day was intensely hot; yet about two hundred men were at work in the full glare of the sun—some with tin pans, some with close-woven Indian buckets, but the greater part had a rude machine known as the *cradle*. This is on rockers, six or eight feet long, open at the foot, and at its head has a coarse grate or sieve; the bottom is rounded with small cleets nailed across. Four men are required to work this machine: one digs the ground in the bank close by the stream; another carries it to the cradle and empties it on the grate; a third gives a violent rocking motion to the machine; whilst a fourth dashes on water from the stream itself. The sieve keeps the coarse stones from entering the cradle; the current of water washes off the earthy matter; and the gravel is gradually carried out at the foot of the machine, leaving the gold, mixed with a heavy fine black sand, above the first cleets. The sand and gold mixed together are then drawn off through auger holes into a pan below, are dried in the sun, and afterwards separated by blowing off the sand. A party of four men thus employed at the lower mines averaged a hundred dollars a day. The Indians, and those who have nothing but pans or willow baskets, gradually wash out the earth and separate the gravel by hand, leaving nothing but the gold mixed with sand, which is separated in the manner before described."

Another scene well illustrates the mode in which a solitary unassisted adventurer—without companions, servants, machines, or capital—often acts. A person without a machine, after digging off one or two feet of the upper ground near the water (in some cases they take the top earth), throws into a tin pan or wooden bowl a shovelful of loose dirt and stones; then, placing the basin an inch or two under water, continues to stir up the dirt with his hand in such a manner that the running water will carry off the light earth, occasionally with his hand throwing out the stones; after an operation of this kind for twenty or thirty minutes, a spoonful of small black sand remains; this is placed in a handkerchief or cloth and dried in the sun, and, the loose sand being blown off, the pure gold remains. By such rough processes has much of the golden wealth been procured. In some cases a gulley or gutter, a hundred yards long by four feet wide, has yielded a thousand ounces of pure gold, disseminated in fine grains among the sand and mud.

But the Anglo-Saxon race was not likely to leave matters in such a primitive state as California presented in the first paroxysm of the gold fever. Various machines have been from time to time introduced, calculated to expedite proceedings and to economise labour. Various machines for this purpose have been recently introduced. Prince Demidoff sent one for deposit at the Great Exhibition. A Californian gold-winnowing machine, of a neat and ingenious kind, was invented in France about a year ago, for the use of such of our Gallic neighbours as wish to try their fortune in the "diggings." In any such machine, to be effective, there must be a mode of supplying water to the auriferous mud, and a means of agitating the mixture thus produced. Now the French machine effects these two purposes by one move-

ment: there is a kind of hopper or receptacle into which the sand is shovelled, and from which it descends into a cylinder or barrel; this cylinder is made to rotate by a winch handle, which handle also works a pump for raising water into the cylinder. The mud and sand are washed out by the continual agitation of the cylinder, and the golden particles are left behind.

California has taught us a few strange things, and none stranger than the effect of the gold discoveries on *prices*. The relative value which gold bears to other commodities depends on the same law of supply and demand as commercial value generally. This was never better shown than in the extravagant quantities of gold-dust (or its equivalent in silver dollars) paid in California for every-day commodities and services. Mr. Kelly, in one of his rambles through the golden land, came to a spot where many diggers had congregated, and where a few stores were opened for their accommodation. The state of the roads and rivers rendered it improbable that new supplies could be obtained for many days; and the store-keepers therefore combined to raise their prices to a most extravagant pitch. "Flour jumped up from 50 cents. per lb. to 1 dollar 50 cents.; pork, from 40 cents. to 1 dollar 25 cents.; beans, coffee, sugar, mackarel, and all other indispensable neccssaries, in the same proportion; together with boots, which were in great demand, and for which they charged two ounces for the commonest pegged manufacture." These "two ounces" refer to gold, so that common shoes were five or six guineas per pair; while flour was six shillings per pound. There was a violent commotion among the diggers; but, as they could not help themselves, except by actual robbery, they not only acquiesced in these prices, but witnessed another rise of 100 per cent. a few days afterwards. A single additional boat-load of provisions drove down prices nearly to their original level.

On another occasion Mr. Kelly had a curious illustration of the value of domestic service. He came to a settlement formed by a Mr. Hudspeth, where a young English girl was engaged as housekeeper; she had left the Mormon settlement at the Great Salt Lake, and joined an emigrant party to California. She was, as our informant describes, "an admirable cook, and made the nicest butter I ever used, for which services she was requited by the liberal salary of 1000 dollars per year, and the right to dispose of, as her proper perquisites, all the milk, butter, cheese, and eggs that remained after supplying the wants of the household. Those, she admitted to me, according to the amount they then realized weekly, would increase her yearly income to 2500 dollars: this, on explanation, did not surprise me, as she obtained twenty-five cents. a piece for eggs, which sometimes got so high as fifty; one dollar per quart for milk; four dollars for butter; and I forget how much for cheese: then the overplus of each must have been immense, from the legions of hens about the premises and the incredible number of calves I saw in the corral; while the constantly passing waggons, pack companies, and whale-boats, never suffered a stock to accumulate or spoil in her hands. Only think," exclaims Mr. Kelly, "of £500 a year, ye cooks and dairy-maids of Old England!"

It would carry us out of our path to dilate further on the relative value between gold and other commodities in California; but we may state that Mr. Kelly saw, at San Francisco, a fine merchant vessel, of a thousand tons burden, fitted up as stores, warehouses, and counting-houses; the owner had found it utterly impossible to procure a crew to navigate the vessel, all the seamen having scampered off to the diggings; and, to prevent the vessel from uselessly rotting, he let it out, in the way above noticed, at rents so high as to far overbalance any profit derivable from ordinary freight.

Will California yield gold for ever? If not, will it, for ages to come, present a profitable field for gold-seekers? Some of the writers on California indulge in the most extravagantly glowing pictures on this subject. But let us hear what a deservedly great authority says. Sir Roderick Impey Murchison has examined with great attention the gold deposits of Russia, and all the circumstances connected with their geological position; and he has also studied all the accounts which have been given of similar deposits in other countries. In 1849 he gave an outline of his researches to the British Association, at Birmingham; he told that learned body all about the Ural Mountains, and the gold therein contained; he compared the Russian with the Californian regions; and he expressed the following conclusion:—A periodic discovery, like that in California, may, in the hands of adventurers and unbridled speculators, force a considerable quantity of surface gold so suddenly upon the market, that a momentary apprehension of a great change in its relative value may be entertained; but, looking to the mineralogical and geological structure of America, and seeing how large a portion of that continent is made up of rocks precisely similar to those which have afforded the gold shingle and sand of the Sacramento; and, knowing that all the other far-famed gold districts of the New World have had assignable limits in their productive capacities, and that many of their sources have disappeared or become valueless, he believes that the time will come when the rich soil of the valleys of California, like the banks of the Rhine, the Guadalquiver, and the rivers of Bohemia, will be turned up by the plough alone, or serve as pasture land, to the entire abandonment of gold hunting.

## The Recent Australian Discoveries.

If this sheet had been written a few weeks ago, the name of Australia would, perhaps, not have been mentioned in it. But a new gold-fever has sprung up. While England has been glorying in her Great Exhibition, Australia has run mad after the diggings which nature has vouchsafed to her.

It was in September, 1851, that the news reached England of gold having been found in Australia—that is, gold in large quantities: a golden region. Early in May the announcement was made at Sydney, by letters from Bathurst, and the effect was quite electric. A mining mania seized every one. On the Monday morning after the Sydney papers announced the discovery, "groups of people were to be seen," we are told, "at every corner of the streets, assembled in solemn conclave, debating both possibilities and impossibilities, and eager to pounce upon any human being who was likely to give any information about the diggings. People of all trades, callings, and pursuits, were quickly transformed into miners; and many a hand which had been trained to kid gloves, or accustomed to wield nothing heavier than the gray goosequill, became nervous to clutch the pick and crow-bar, or 'rock the cradle' at our infant mines. The blacksmiths of the town could not turn off the picks fast enough, and the manufacture of cradles was the second briskest business in the place. A few left on Monday equipped for the diggings; but on Tuesday, Wednesday, and Thursday, the roads to Summer Hill Creek became literally alive with new-made miners from every quarter; some armed with picks, others shouldering crowbars or shovels, and not a few strung round with washhand basins, tin pots, and colanders: garden and agricultural implements, of every variety, either hung from the saddle bow or dangled about the persons of the pilgrims to Ophir. Now and then a respectable tradesman,

who had just left his bench or counter, would heave in sight, with a huge something in front of his horse, which he called a cradle, and with which he was about to rock himself into fortune. Scores have rushed from their homes provided with a blanket, a 'damper,' and a pick or grubbing-box, full of hope that a day or two's labour would fill their pockets with the precious metal; and we have heard of a great number who have started without any provision but a blanket, and some rude implements to dig with."

The land of expectation, to which these gold-thirsty adventurers were wending, is situated nearly due west of Sydney, separated from the sea coast by the ridge of the Blue Mountains, over which all settlers must pass to reach the vast sheep plains around Bathurst. Mr. Stutchbury, a geologist employed by the Government, and Mr. Hargraves, were the first to make the golden announcement. Mr. Hargraves "washed several baskets of earth, and procured gold therefrom." A young man picked up a lump of pure gold, weighing eleven ounces; an old man gathered lumps which, altogether, weighed nearly three pounds; and the Manager of the Bathurst Branch Bank, who went to see with his own eyes what the truth actually was, brought away several small pieces of gold with him. It was the announcement of these facts that drove the Sydney people almost out of their wits.

That gold exists in Australia had been long surmised by Count Strzelecki, one of the best writers on that immense region. Sir R. I. Murchison, too, whose authority on these points we have just adverted to, had expressed a similar opinion. Many months ago an old shepherd, who visited Sydney from the Bathurst district occasionally, seemed to possess more money than was easily accounted for by those who knew him; and it is now believed that he had picked up bits of the gold treasure, but had kept his own secret. Mr. Hargraves, who had long been familiar with the geology of the Blue Mountains, and who has since spent a year and a half in California, was so struck with the analogy between the two districts, that on his return to Australia he resolved to search for himself. He set out in January last from Sydney, travelled three hundred miles on horseback, and found a little gold on the very first day of his "digging." He selected a particularly favourable spot, which he called by the oriental hope-exciting name of Ophir, and organised a body of nine persons, by whose aid he procured the specimens of gold which he sent to Sydney.

All these golden pictures speedily dazzled the eyes of the Sydney folks. Servants left their situations, and thus wages rose; while the price of flour and other provisions also rose; and thus the Sydney tradesmen and families have been suddenly placed in a somewhat perplexing position. That only a small percentage of those who have set off to the diggings will become successful gold-finders, is admitted by all; yet the mere circumstance of such a sudden departure of numbers from Sydney is enough to disturb the ordinary run of trade. The next newspaper account from Bathurst stated that one little man, "a shrimp of a fellow," with a forked stick and an old frying-pan raked up five pounds' worth of gold in half a day; and it also gave the information that bacon would fetch 3*s.* and flour 1*s.* per lb. at the diggings. It also recorded the golden result of a matrimonial quarrel; for a man, wrathful against his better half, walked off to the diggings for the purpose of annoying her: from which diggings he speedily returned with gold to the value of £170.

The later accounts received in England from Sydney state that, by the end of May, there were not less than two thousand persons at the Ophir diggings (Ophir is 35 miles north-west of Bathurst, which is itself 113 miles west of Sydney); but no estimate could be formed of those who were going

or about to go. No good guess, either, could be made of the quantity of gold obtained, for the successful diggers showed a disposition to conceal the amount of their gains. Five Bathurst magistrates formed a party (for gold-digging has attractions for professionals as well as for humbler folks), whose labours among the gold dust are said to have netted many thousand pounds. Three or four Sydney dealers purchased £900 worth at Ophir, from a few diggers. The largest piece (pure, virgin gold) transmitted to Sydney up to that time weighed about forty-six ounces. Three apprentices, who ran away from Bathurst, returned in a few days with gold which they sold for £51.

But as "all that glitters is not gold," so is no glittering gold procured without some heavy drawbacks. The discovery at Ophir was announced one month too soon for husbandry prospects; the agricultural labourers ran away to the diggings, and left the corn to take care of itself, or rather left the ploughing and sowing half done (Australian winter occurs contemporaneously with our summer). The shepherds, too, took leave of their flocks with very little ceremony. One Bathurst farmer said, "We are in the greatest excitement here; some from joy, some from despair, anticipating famine, disease, confusion, and death; I am glad to hear that the military are coming up." One stock-holder, possessing thirty thousand sheep, lost all his shepherds at one start, and knew not how to protect his flock from the native dogs. Another Bathurst inhabitant wrote, "the people are all mad;" and Mr. Hargraves wrote, "even California did not equal the excitement and confusion which at this present moment surround me." One of the Bathurst journals, the *Empire*, speaks of its compositors and its printers' devils as "having, just now, their brains stuck full of lumps of gold," to the great derangement of the printing-office and its labours. Another Bathurst writer said, "Trade is quite at a stand-still, except with the storekeepers and publicans, and every consumable article is enormously dear." Some of the diggers returned from the mines, "with a little bit of gold, and a bellyful of hard work and starvation;" and said, that none but those who could bear severe labour, exposure, and scanty allowance, could do well at the diggings in winter. Women had started off from Bathurst to Ophir on a laundry speculation, which was expected to pay well. One dark and dismal feature is, that there is scarcely a tree or a blade of grass within twenty miles of Ophir: it is little else than a perfect desert, in all except gold and excitement.

Really scientific men are among the best prophets of all ages; for, arriving at general principles by a careful comparison of the past and present, they are often able to predict future phenomena or anticipate future discoveries, with a correctness quite inconceivable to the non-initiated. Murchison, without ever having been in Australia, predicted that gold would be found there; he drew inferences from the geological character of various regions, founded on the analogy of similar regions elsewhere. In the paper read to the British Association, in 1849, referred to in another page, he said: "In considering the composition of the chief or eastern ridge of Australia, and its direction from north to south, he had foretold (as well as Colonel Helmersen, of the Russian Imperial Mines,) that gold would be found in it; and he stated, that in the last year one gentleman, resident in Sydney, who had read what he had written and spoken on this point, had sent him specimens of gold ore found in the Blue Mountains; whilst from another source he had learned, that the parallel north and south in the Adelaide region, which had yielded so much copper, had also given undoubted signs of gold ore. The operation of the English laws, by which noble metals lapse

to the crown, had induced him (Sir Roderick) to represent to Her Majesty's Secretary of State that no colonists would bestir themselves in gold mining if some clear declaration on the subject were not made; but as no measures on this head seem to be in contemplation, he infers that the Government may be of opinion, that the discovery of any notable quantity of gold might derange the stability and regular industry of a great colony, which eventually must depend upon its agricultural products." It *may* be so; but the sluggishness of all our colonial arrangements induces a conjecture, that the Colonial Office thought nothing and did nothing in the matter. Now that the discovery is actually made, however, it behoves the colonists to ascertain exactly what are their relations to the mother country in respect to gold-mining laws.

This they are now enabled to do by a proclamation, issued by Governor Fitzroy on May 22. The document states, that all gold mines in the British dominions belong, by law, to the Crown; that no gold is to be removed from the leased lands without Government permission; that no gold is to be either removed or êxplored for in the unallotted Crown lands, without similar per mission; that offenders against these orders would be proceeded against, both civilly and criminally; and that licences will shortly be issued to gold-seekers, at definite fees or royalties, and under definite arrangements. This has been now done; thirty shillings per month being charged for the licence.

That Australia has a bright future marked out for it, is pretty evident; for, if the gold workings should not be so large as is now expected, there will yet have been a vast stream of emigration to a colony which, under anything like judicious management, will yield abundance for all.

### How the Gold-Dust and Ore are treated.

Five or six millions of inquisitive human beings have had an opportunity of seeing virgin gold, gold ore, or quartz gold, at the Great Exhibition. Perhaps not one-thousandth part of this number had ever seen such treasures before. Those who missed the ponderous Californian specimen, whose pounds weight were in hundreds, and whose pounds value was in thousands, had yet an opportunity of seeing those which glittered among the Russian treasures; while those who looked narrowly into the various mineral collections, may have seen the humbler bits of the precious material from Canada, from Chili, or from Western Africa.

But we must hasten on our golden journey. The present is not a work treating systematically of metallurgic operations; and we shall therefore travel rapidly over the interval which separates the gold-digger from the goldsmith—the finder from the user.

When a rock is supposed to be auriferous, or when the sands or other alluvial matter of a district are to be examined for gold, the adventurer is advised by Professor Ansted to proceed in a certain systematic course. The counsel is given in the small but interesting 'Gold-Seeker's Manual,' written by that skilful geologist. The treasure-seeker must first break off a piece of rock, pound it, and sift it; the dust thus obtained is to be washed in a shallow iron pan. If any gold is present it will sink to the bottom, and the rest may be washed over the edge of the pan. If the quantity is too small to be separated and weighed, it is treated by the amalgamation method with quicksilver, and finally isolated. The adventurer can then determine, by the ratio between the weight of the gold and that of the original piece of rock, what percentage of gold exists, and whether it will pay for extraction. Of course all this can-

not be done by a solitary rambler to the "diggings," who has got all his worldly wealth on his back; the breaking and pounding and washing may be so conducted; but the amalgam process requires other resources. In proportion as the rock or the sand is rich, so will washing suffice for the extraction of a profitable quantity of gold.

In the gold districts of Hungary, the sand is placed upon an inclined table, the surface of which is grooved with transverse channels. Water is thrown on the sand in the uppermost groove; and after a time the golden particles find their way (by their superior weight) down the table to the lowest channel, where they collect with some of the sand, from which they are afterwards easily separated.

In Brazil, where gold-working has been more steadily and extensively pursued in modern times than in any other country, the mining operations have gone through three epochs or periods. The first was before the year 1724. The common method of proceeding, as described by Professor Ansted, was to dig a square hole in the soil, until the miners came to the auriferous gravel. The gravel was broken up with pickaxes, and shovelled into wooden vessels. These vessels were exposed to the action of running water, and were shaken from side to side until the earthy particles were washed away, and the gold subsided. These workings were either in the beds of rivers, or in the alluvial banks over which rivers had in former times flowed.

But in 1724 a new method was introduced, which economised labour. Instead of opening the ground, and carrying the auriferous gravel to a running stream, a stream was conveyed to the gravel; water was conducted to the mining ground, and made to wash away the mould which covered the gravel; after which it washed the gravel itself away from the golden particles.

The comparative exhaustion of the sands led to the adoption of a third mode of mining in the Minas Geraes district. It was known that the mountains near the rivers contained veins rich in gold; but the means for working have been and still are very rude. The working is by open cutting, laying the vein bare by clearing away the surface. Unless there is water to aid in this operation the labour becomes immense.

In one district of Brazil the gold is collected in a singular way. Canoes are provided, each cut out of a solid tree. The gold-washers dredge up sand from the river bed into the canoe, by means of a windlass and an iron scoop; and into the sand thus collected they direct a stream of water through bamboo shoots. The sand and mud become gradually washed away, and the golden particles are found in the bottom of the canoe. It seems, however, that the produce thus obtained is only just sufficient to pay for the expense of obtaining it.

In some districts, where the river banks are not private property, negro gold-seekers work on their own account in the following way. They are dressed in a leathern jacket, and sling before them a leathern bag and a round bowl. They select localities where the river is not rapid, or where it has bends or deep holes. They first remove the large stones and upper layers of sand with their feet; and then take up a bowlful of the deeper and older gravel. They wash and shake the contents of the bowl until all the gold sinks to the bottom; and when it is separated as far as possible from sand, it is taken out of the bowl by hand, and put into the leather bag.

It must not be supposed that gold presents itself to the eyes of the eager adventurer in its pure metallic form; it is almost always deteriorated, either with earthy matters or with some of the cheaper metals; and this deteriora-

tion may arise either simply from mechanical mixture or from chemical combination. Hence many different processes have to be adopted, to bring the gold to absolute purity. The "diggers" and adventurers care and know very little about these processes; they know that they can sell their gold dust and gold ores, whether the ratio of pure metal be large or small: receiving a price which (ostensibly at least) depends upon this ratio.

One of the simplest modes adopted in Brazil for effecting the separation is thus managed:—The river sand and mud are well washed, until the gold appears as very fine grains. The gold is put into a crucible, sublimate of mercury is added to it, and it is melted; the time required in melting depends on the kind of metals with which the gold is alloyed; but when the melting is completed, the precious liquid is poured into iron moulds, or, rather, the cheaper and lighter metals are poured off, by which they are separated from the heavier gold.

But the separation of gold from a rocky ore is a more difficult matter, and requires appliances which a Californian digger is very little likely to have at hand. The ore is pounded and ground to a fine powder; it is washed, to expel the light earthy matter; the residue is dried, and is mixed with a certain quantity of quicksilver; by a gentle heat the mixture is gradually melted, and an amalgam formed. Then comes a very curious process: the amalgam is pressed in a leather or skin bag; the quicksilver mostly passes through the pores, but the gold remains behind; and, by further processes, the whole of the mercury is recovered from the leather, and the whole of the gold is separated from impurities and alloys.

The gold-mining system of Russia, as described by Mr. Cottrell, is curiously managed. Every freeman in Russia, except a Government *employé*, is allowed to search for gold, which is usually found in the sands on the banks of rivers. If an explorer finds that his search has been successful (in any district not before similarly appropriated), he announces the fact to the Government, and applies for permission to avail himself of the discovery. A mining officer is sent to examine the spot, and to mark out a district of about two English square miles, of which the explorer is put into possession, so far as regards gold-getting. The speculator (for it can only be a moneyed man who enters on such a project) builds huts for workmen, fixes machines and offices, and lays in large stores of provisions; for the location is often many miles distant from any town. The labourers are mostly persons exiled from Russia to Siberia; and they receive good but not extravagant wages from the speculators The sands are collected and washed, and the gold is brought to as clean a state as possible. At the fall of the year, when the increasing cold brings the operations to a close, the gold is carried to a government establishment, in a particular town; it is weighed, registered, melted, moulded into ingots, assayed, and accurately valued; the ingots are transmitted to St. Petersburgh, and coined into money, which is paid to the speculator, minus a certain percentage retained by the Government. It appears that the Government, being desirous to encourage these operations, does not press very hardly on the speculators. The adventure, however, is a precarious one; for sometimes the returns do not pay the expenses, while at other times a capitalist is ruined before the gold appears in any quantity. An instance is narrated of one speculator, who spent thirty-five thousand out of forty thousand roubles of borrowed money, before any fruits resulted; but luck then showered upon him so abundantly that, in a few years, he became a millionaire.

## Gold Coinage, and its Curiosities.

Distant as the Californian diggings are from New York and from London, the diggers find abundant customers for their gold-dust. Silver dollars are sent out to San Francisco, in exchange for the dust and the ore; and the magnificent steamers of the Atlantic route bring us as much of this gold as the course of exchange between the countries requires.

Among the many modes of practically applying gold, *money* is not the least curious and interesting. The substances of which money is composed are more numerous than many persons imagine. When society rises above the level of mere bartering transactions, any substance which is equally valued by buyer and seller may become money; and there then arises simply a question of degree, as to the fitness of one or another material. One of the earliest kinds of money was *cattle*, an article being valued at so many oxen; but this is obviously a coin that is inapplicable to small purchasers, for it would puzzle the seller to give change out of an ox. *Shells* are used to a great extent as money, in India, the Indian islands, and Africa; the cowry shells of India have a value of about thirty-two to an English farthing. *Cocoa-nuts*, *almonds*, and *maize* have all had to do duty as money, in certain times and countries. In hunting countries, *skins* are a very common kind of coin; and stamped pieces of *leather* are said to have been used in England in the time of Edgar. In some regions *salt* is used as money, cut into convenient brick-shaped pieces. In countries where rents and wages are estimated in given quantities of *corn*, corn may be said to be money, *Dried fish* is often the money of Iceland and Newfoundland; *sugar* has at times been a West-India money; and Adam Smith tells us of a Scotch village in which *nails* were a current coin at the ale-house and the baker's. But metals supersede all the above heterogeneous list, in a more advanced state of society. *Brass* money was made in Ireland during the time of the Tudors; and at the same period *lead* was used for small coins in England. Charles the Second had farthings of *tin;* and his successor had small coins of *pewter* and of *gun-metal*. *Iron* was used by some of the early nations; and *platinum* is used at the present day in Russia.

It appears, therefore, that, besides silver and copper, gold has many rivals as materials for coins. All yield precedence to it, however; for no other metal possesses at once so many qualities fitted for this purpose. It is very solid and dense; it is divisible or separable in an extraordinary degree; it is very little affected by air or moisture, or ordinary usage; its supply is (relatively) very limited; and its value presents a remarkable approach to uniformity, in different countries and different times.

Our modern potentates, in England at least, have no trouble to obtain gold for coining; bullion dealers, in the ordinary course of their trade, voluntarily bring gold to the Mint to be coined. But such was not always the case, in earlier times, nor is it now always the case, in other countries; for the rulers thought it incumbent on them to place some check upon the locomotive propensities of gold. Sometimes gold was not allowed to be sent out of the country; sometimes a bonus was offered to the holders of gold, to permit it to be coined; and sometimes an interdict was put against the use of gold for trinkets and ornaments.

Perhaps the most intense gold-fever the world has known—not so widely spread, perhaps, but more deep than that of California—was *alchemy*. When

men thought that common cheap metals might be transmuted into gold, no wonder that they racked their brains to discover the chemical means of effecting the transmutation. The world possessed many Oldbucks and many Dousterswivels, the deceived and the deceivers, among the alchemical craft. How the ardent students of this mystery carried on their researches, sober history or pleasant romance have made familiar to most readers; but it is not, perhaps, so generally known, that among our English monarchs, Edward III., Henry IV., Henry VI., Edward IV., and Henry VIII., all showed a tendency to believe in the transmuting power of alchemy; and they looked with a longing eye to the possible enrichment of their exchequer by these means. Edward III. encouraged the alchemy of Raymond Lully, until hopes were dashed by failure. Henry IV. seems rather to have feared the art than to have relied on it as a state engine. Henry VI. "patted on the back" certain alchemists, who promised him a golden return; but on their failure he appointed a commission of inquiry, as strangely constituted as any known in our country; for it consisted of two friars, the Queen's physician, a schoolmaster, an alderman of London, a fishmonger, two grocers, and two mercers. Mr. Ruding, who notices this commission in his 'Annals of the Coinage,' was not able to discover any record of the results of the enquiry. That this goodly cluster of Henrys and Edwards failed to make gold by the transmuting process was, perhaps, after all, more a subject of regret than of surprise to them; for it is no easy matter to detect the cheaters from the cheated among the worshippers of the "philosopher's stone," and these monarchs (or at least some of them) may possibly have belonged quite as much to the former as to the latter class.

*Bullion, sterling, standard,*—all are terms employed in connection with gold as a coined metal, or as a metal about to be coined; and they let us into some curious facts concerning gold coinage. When a bullion dealer or an accountant speaks of *standard* gold, or a jeweller praises his goods as being made of *fine* gold, what is meant by these terms? And what is *sterling*? And are "standard," and "fine," and "sterling," three names for the same quality? Perhaps these questions have not been put exactly in this form, but the subject of them must have occurred to many persons. The word *sterling* has now very little other meaning than as a name for English coined money; so that a pound sterling means an English pound coin; but originally it had a little wider meaning. A pound in money was, Mr. Ruding tells us, in early times in England, equivalent to a pound of silver, that is, lb. (silver) and £ were equivalent; but when this equality was, from various causes, disturbed, the word *sterling* was used to designate the coined silver money, whether of pure silver or not; and the same name became afterwards applied to gold. *Standard* expresses the degree of fineness in gold. For coining purposes, gold is almost invariably alloyed with a little silver and copper, which render it less flexible and more durable. A *carat*, in gold assaying, is an imaginary weight or rather ratio; any piece of gold is supposed to weigh twenty-four carats, and the fineness is expressed by the number of carats of pure gold; it is in fact only a peculiar mode of expressing the purity of a gold alloy. At different times the *standard* of English gold coins has varied greatly; but for a long period back it has uniformly been "twenty-two carats fine;" that is, out of every twenty-four parts by weight twenty-two are fine or pure gold, the remaining two being copper and silver. The *fine* gold of the jeweller is as nearly pure as can conveniently be wrought into durable forms; but ordinary *jeweller's* gold is much alloyed.

Although gold coin, for this country, is made only at the Mint, yet Bir-

mingham is in some respects the head-quarters of the coining art in modern times, chiefly through the famous establishment of Boulton and Watt, at Soho. Birmingham produces an immense quantity of stamped work in brass and other metals; and the die-makers, who make the stamps for this process, are merely a humbler grade of those who make the dies for coins. The dies are cut in hard steel by hand, a laborious and tedious operation. In the last century, the famous Soho establishment not only coined copper money for the English government, but money of various kinds for foreign governments. The dies were produced by men very eminent in that line; men who, indeed, have rightly obtained a niche among artistic worthies. The great establishment, which had suffered much decline, as one after another wealthy partner retired from it, was finally broken up by an auction sale in April, 1850; and on that occasion the lots exemplified the former extent of the coining arrangements. There were some of the most celebrated medals which had appeared in various European countries during the reign of George III.; the dies by which these medals had been stamped; British copper coins, and the dies for them; many varieties of French copper coins, with the dies; and a great variety of other coins, medals, and tokens. Birmingham still makes copper coins, by the ton weight at a time, for various countries. When Boulton and Watt commenced coining in 1787, they had eight cutting-out presses and eight coining processes. On one occasion the firm coined many tons of five-shilling pieces for the British government, of the silver obtained by the capture of a Spanish galleon; a troop of soldiers guarded the premises while the coining was in operation.

But it is only of gold—the shining tempter, gold—that we have here to speak. The actual processes of coining are too minute and technical to be described here: they fittingly find a place in cyclopædias, where the alloying, the melting, the casting, the rolling, the cutting, the stamping, the milling, the assaying, the weighing—all come under notice in their proper order. But there is one curious matter relating to the career of gold coins after they come into the hands of the public, which is worth a little attention.

The wearing away of gold coin, by the constant friction to which it is exposed, is a curious matter both mechanically and financially. No one can say whither the worn particles go: the pocket, the purse, the skin of the hand, the wooden till, the metal cash box—all must rob the golden sovereigns of something of their weight; but we cannot see the process of diminution, nor catch the truant particles as they fly. Then, when gone, somebody must bear the loss; and who shall this be? A baker who takes a sovereign one day, and pays it away to his miller the next, does not pay the veritable sovereign itself: it is a little lighter than when he received it; and, although even Mr. Cotton's exquisitely delicate apparatus might not be able to detect the amount of deficiency, yet deficiency there is, and several repetitions of it amount to an appreciable quantity.

From very careful investigations made by the officers of the Mint towards the close of the last century, it was found that $78\frac{1}{10}$ silver shillings, taken as a fair average from all those then in circulation, were required to make 1 lb. troy; whereas 62 is the number when new. Eleven years afterwards another fair average was taken, and another examination made, when it was found that $82\frac{9}{40}$ shillings were required to make a pound. But this diminution of weight is excessive, and is not likely to be exhibited by the less-worn and more frequently-renewed silver coinage of the present day. Still it is unquestionable, that the gold and silver coins are exposed to daily wear and diminution. The

Government requested Mr. Cavendish and Mr. Hatchett, two distinguished fellows of the Royal Society, to make an extensive investigation respecting the power of metals to resist friction; and their results are highly curious. They made various alloys of silver, copper, platina, iron, tin, lead, bismuth, manganese, nickel, cobalt, zinc, antimony, and arsenic, with gold; they rubbed plates of different kinds of metal over each other half a million times, to determine which resist friction best; and they rotated similar pieces among each other in a barrel. The effects were such as to reflect no little credit on those, whoever they were, who established the standard of English gold coin; for the English standard (22 gold to 2 alloy), and the quality of the alloy (silver and copper combined), were found about the best of all the combinations subjected to experiment.

In 1807 the Mint officers, wishing to ascertain how much the current coin had actually lost by wear, selected at random one thousand good guineas from a banker, and found that they had lost on an average 19*s*. per cent. in value. A hundred guineas from a shopkeeper's till had lost 22*s*. per cent. Two hundred half-guineas exhibited a loss of 42*s*. per cent—the smaller coins being subjected to more severe wear than the larger. Mr. Jacob, a great authority on the subject of the precious metals, has stated it as his opinion that, taking the average of all the gold coins in this country, and an average of all the hard usage to which the coins are exposed, each one bears an *annual* loss of about $\frac{1}{900}$ by friction, which is a little more than a farthing in the pound. In silver coins the loss is supposed to be five or six times greater, owing to the more unceasing circulation of silver than gold, and to the less fitness of the metal to bear friction. The matter may be stated thus: put 900 new sovereigns and 900 new shillings into average ordinary circulation; in twelve months' time the former will be worth about 899, and the latter about 894.

The extraordinary delicacy of the machine invented by Mr. Cotton for weighing gold coins, the motives which led to its adoption, and the mode of its operation, are briefly noticed in the paper on *Calculating Machines*.

## The Art of the Goldsmith.

How bravely soever our Hunts and Roskells and Garrards may compete with them, it is not probable that we shall ever equal the golden glitter of the east and the south. We do not care for it. What a daily journalist said of the Turkey and Egypt compartment of the Great Exhibition, may be said of oriental countries in général. "Gold, in every shape and form, here glares upon the eye,—we have it spun into thread, arranged in embroidery, lavishly scattered over every species of fabric to which gold can be applied—jackets all stiff with the glittering metal—saddles like burnished thrones—housings for camels and trappings for horses gorgeous as the state tabard for heralds—caftans, turbans, bernouses, nusmuchs—all bespangled with the veritable ornament. You see gold gleaming from the long rifled barrel and the superbly carved stock—gold 'dimming the sheen' of the Damascus blade and the Maltese poignard—gold adorning the pipe-stem and the walking-staff—gold upon the harness of the 'ship of the desert'—gold upon the accoutrements of his rider, from the aigreth of his turban to the pointed weapon of his unwieldy stirrups—gold encrusting the lady's slipper—gold gleaming from the tiny coffee cup, and decorating the ample vase—gold worked into the hangings of the divan—gold fringes, gold tassels—gold plated, wrought, inlaid, embroidered —gold in every possible combination of ornament and device. This taste for

lavish gold embroidery and ornaments is characteristic of all the Eastern people."

But though we do not possess (because we do not attach importance to) such indiscriminate applications of gold, we have golden realizations of artistic design such as the East possesses not. The art of the goldsmith, from the time of Benvenuto Cellini, has been ever wedded more or less to that of the sculptor; and the great industrial display of 1851 has shown what fine results England, France, Germany, and other countries, are able to present in this department of art-manufacture.

The munificent offer of the Goldsmiths' Company, in connection with the Great Exhibition, ought to have been imitated by some of the other wealthy city guilds, the revenues of which are but too slenderly applied to the fostering of the "arts and mysteries" whose name they bear. The Goldsmiths' Company offered prizes, to the amount of one thousand pounds, for the best specimens of workmanship in certain specified kinds of gold and silver work. These were to be candelabra, with groups of figures or animals, not less than 500 ounces in weight; other candelabra of smaller weight; shields, salvers, side-boards, or dishes, of 22 inches or more in length; dessert services; sideboard ewers; ornamental cups; entrée dishes; candlesticks and branches; tea and coffee services; communion plate; table candlesticks; salts, claret jugs, bread-baskets, teakettles and stands, ink-stands, spoons and forks—each kind having its own defined prize, and sometimes three gradations of prizes. All were to be modelled and made by British artists, but it was left to the competitors to adopt gold or silver, or silver-gilt, as the material. Those who were familiar with the gorgeous display in the south-west gallery of the Exhibition (a display which has been roughly valued at upwards of a million sterling) will remember to have seen bits of orange-coloured ribbon attached to some of the articles of plate; these marked the specimens which are to compete for the Goldsmiths' Company's prizes. And sumptuous, indeed, are many of them. How many claret jugs and cups, tea services and coffee services, salvers and dishes, candelabra and groups, there are—we cannot venture to say; nor ought any but a deeply-versed connoisseur to pass judgment on their relative merits. The subjects depicted on some of the gold and silver plate were as varied in character as they were beautiful in effect. There was a Bacchanal group for a claret jug; there was the never-dying Sir Roger de Coverley, and the equestrian virgin Queen Elizabeth; fables from Æsop in alto-relievo; Mr. Cotterell's design of the labours of Hercules, executed in silver by Messrs. Garrard; a scene from Scott's 'Talisman;' Britannia and her sister goddesses; the Anglo-Saxons battling against the Normans—all were among the tales told or the personages set forth in gold or silver.

One circumstance which contributed to render the display of precious metals peculiarly rich in the British department, was the permission given to the chief goldsmiths to exhibit the honorary or prize trophies on which so much artistic labour is always bestowed. We allude, of course, to the racing cups, and to the presentation plate given to individuals for public services rendered. It was thus that the Exhibition became graced with the magnificent silver trophy presented to Sir Moses Montefiore—designed by Sir George Hayter, modelled by Mr. Baily the sculptor, and made by Messrs. Hunt and Roskell: a rare combination of talent. It was thus, also, that we had an opportunity of seeing the plate presented to Lord Ellenborough by the East India Company; the graceful silver column presented to Mr. Lumley by the performers at the Opera House; the salver presented to Mr Brassey by those

employed under him as a railway contractor—a salver which has a peculiar interest attached to it, in respect to twelve enamelled portraits of the leading engineers of the day; and one or two others of similar kind. The Emperor of Russia's Ascot prize for 1847 was one of the most conspicuous and beautiful of the race-cup species.

In what way these brilliant and splendid productions are wrought, we do not propose to trace very minutely here. Suffice it to say, that the articles are either cast in molten metal, or are hammered and stamped from sheets, and are afterwards brought to a highly-finished state by chasing, engraving, and burnishing. Such is the case when a vase, or salver, or ornament, is made of solid gold, and such is it likewise when made of silver and coated afterwards with gold; but silver plating involves other processes of a singular character. An ingot of white metal is made: on its surface is laid a plate of silver about one-fortieth part as thick as the white metal; the two are soldered together by heat; the compound ingot is brought to any required thinness by rolling; and the silvered sheet so produced is stamped, punched, hammered, engraved, and burnished into the required form and appearance. The white metal forms the foundation, the silver forms the glittering surface, and this silver could itself be coated with gold by what is called the *water-gilding* process, in which aquafortis and mercury are employed to aid the adhesion of the gold to the metal beneath.

The *repoussé* work of French silversmiths, which is equivalent to English *chasing*, is a very remarkable mode of decorating gold and silver plate. It is effected entirely by the hammer. The workman has a plain flat sheet of silver to work upon, and before him is a carefully executed wax model of the article to be produced; the silver plate rests upon a soft bed of pitch or other composition, and with a small hammer the workman produces indentations over the surface corresponding with the device to be produced. A small steel punch is employed occasionally; and if any of the indentations are carried too far, the plate is reversed, and a little counter-hammering applied. Many of the shields, salvers, dishes, and other articles in the Great Exhibition, displayed fine examples of this kind of work; and there was an equestrian statue of Queen Elizabeth produced almost entirely by this remarkable process.

A remarkable department of the goldsmith's art has recently come much into fashion, viz., the manufacture of ecclesiastical plate and ornaments. As we have now church needlework and church brass-work, so have we church-work in the precious metals, such as was little patronized twelve or fifteen years ago. The causes which have led to this novelty, or rather revival, it is no part of the present sheet to discuss; we view the fact simply in connection with a particular department of industry. The communion plate of English churches—the chalice, the paten or salver, and the flagon—had degenerated to very untasteful productions, until within the last few years. There was often abundance of real silver in them, but this silver had not been artistically wrought. It has been remarked, in connection with this subject, that mediæval goldsmiths regarded the metal as one which is to be *hammered* into form, while the moderns have largely practised the art of *casting;* and that, although the last-named process admits of the development of many new and beautiful effects, yet, being easier, it can be accomplished by persons of less taste. In other words, an *artizan* can produce a piece of plate at the present day, whereas an *artist* was required for its production two or three centuries back; and this difference has told on the relative infusion of mind in the two kinds of productions. The church gold-

smiths are now labouring to revive such of the earlier forms and earlier processes as may be deemed by them superior to those adopted of late years. Of course it must remain a matter of individual opinion, whether mediæval taste was better or worse than that of the present century; but the bestowal of thought and study on the ecclesiastical plate of past ages cannot be otherwise than beneficial to the labours of those who are now working in gold and silver, unless it lead simply and solely to a mere imitation, which shows poverty of thought.

The beautiful art of the electro-plater, by which the magic aid of the galvanic battery is invoked by the skilful worker in metal, is briefly noticed in the paper on *Industrial Applications of Electricity.*

## Gold, in its Minute Subdivisions.

Full of interest in an artistic sense as are the productions of the goldsmith, the thousand and one applications of the precious metal to minor purposes are more rich in curiosities, more productive of results which the world in general could not have conceived, and can hardly believe even on assurance of their truth. A few illustrations of these facts call for notice here.

Of all the substances on which man exercises his manufacturing ingenuity, gold is perhaps that which admits of being brought to the most extraordinary degree of fineness. Many of the productions in this department of industry are really "curiosities." Is not a solid, unbroken, uniform sheet of gold, less than one five hundredth part the thickness of a sheet of ordinary printing paper, a curiosity; is it not a curiosity to know that one ounce of gold may be made to cover the floor of an ordinary sitting-room; that one grain of gold will gild thirty coat buttons; and that the covering of gold upon gold lace is very far thinner than even leaf gold? Let us glance a little at these remarkable productions.

And first for gold-leaf and the gold-beating processes whereby it is produced. Gold-leaf, in strictness, it certainly is not: for it is found that a minute percentage of silver and of copper is necessary to give the gold a proper malleable quality—a percentage of perhaps one in seventy or eighty. The refiner manages this alloy, and brings the costly product to a certain stage of completion; he melts the gold and the cheaper alloys in a black-lead crucible; he pours the molten metal into an ingot mould, six or eight inches long; he removes the solidified and cooled ingot from its mould, and passes it repeatedly between two steel rollers until it assumes the thickness of a ribbon; and this ribbon, about one eight-hundredth of an inch in thickness, and presenting a surface of about five hundred square inches to an ounce, passes next into the hands of the gold-beater.

The working tools, the processes, and the products of a gold-beater, are all remarkable. That puzzling material, "gold-beaters' skin," is an indispensable aid to him: it is a membrane of extreme thinness and delicacy, but yet tough and strong, procured from the intestines of the ox; eight hundred pieces of this skin, four inches square, constitute a packet with which the gold-beater labours; and thus he proceeds:—A hundred and fifty bits of ribbon-gold, an inch square, are interleaved with as many vellum leaves four inches square; they are beaten for a long time with a ponderous hammer on a smooth marble slab, until the gold has thinned and expanded to the size of the vellum. How the workman manages so as to beat all the pieces equally, and yet beat none into holes, he alone can answer: it is one of the mysteries of his craft. The

gold is liberated from its vellum prison, and each piece cut into four; the hundred and fifty have thus become six hundred, and these are interleaved with six hundred pieces of gold-beaters' skin, which are then packed into a compact mass. Another beating then takes place—more careful, more delicate, more precise than the former—until the gold, expanded like the silk-worm, as far as its envelope will admit, requires to be again released. The leaves are again divided into four, by which the six hundred become twenty-four hundred; these are divided into three parcels of eight hundred each, and each parcel is subjected to a third beating. Heavy as the hammers are, there are yet degrees of heaviness: first, a sixteen-pounder gives its weighty thumps, then a twelve-pounder, and in this last operation a hammer of ten pounds is employed.

Now if we exercise a little arithmetic, we shall find that the thin ribbon of gold has become thinner in an extraordinary degree; in fact it is reduced to about $\frac{1}{180}$th part of its thickness. A sheet of paper is equal in thickness to 800 gold-ribbons, but one gold-ribbon is equal to 180 gold-leaves; thus the little ingot of two ounces becomes spread out to a very large area. An apartment twelve feet square might be carpeted with gold for six or eight guineas: a thin carpet, it is true, but one of sound honest gold, purer than even standard gold.

The Great Exhibition has not failed to furnish illustrations of this remarkable product, and of the simple contrivances whereby it is produced. M. Bottier, from France, and Messrs. Vine and Ashmead, from the United States, exhibited machines intended to aid in the operations of the gold-beater; but in England these operations are wholly manipulative. Then the delicate membrane, the "gold-beaters' skin," was shown in specimens, not only from our own great metropolis, but from the far distant colony of Van Diemen's Land. In Mr. Marshall's collection, placed among the "precious metals" of the Crystal Palace, there was the packet of eight hundred films of gold-beaters' skin, just in the form in which the hammer is brought to bear upon it; and near this were specimens of all the various kinds of leaf-gold used in manufacturing operations, from the silvery white to the coppery red. These variations of tint are produced by varying the quantity of silver and of copper mixed with the gold; and there were also different thicknesses of leaf, applicable to different purposes. There was gold leaf from three English firms, from France, from the United States, from Turkey, and from Van Diemen's Land—the Old World and the New both displayed their knowledge of this art.

The applications of this exquisitely fine substance are numerous and varied. In the edges of books, in picture-frames and looking-glasses, in the gorgeous decorations of the House of Lords and other sumptuous apartments, in gilt leather—we see some among the many applications of leaf-gold. In all these cases the gold is applied and secured by the aid of a particular kind of cement or gold size; and this cement differs in character, according as the gold is or is not to be burnished with a smooth piece of agate or flint. The whole of the accompanying processes are full of ingenious "Curiosities," both in the effects produced and in the modes of producing them; but we must hasten to glance at one of the other forms of extremely delicate attenuation of gold.

Gold-lace is *not* gold lace. It does not deserve this title, for the gold is applied as a surface to silver. It is not even silver-lace, for the silver is applied to a foundation of silk. Therefore, when we are admiring the glittering splendour of gold-lace, we should, if "honour be given where honour is due," remember that it is silk-lace, with a silver-gilt coating. The silken threads for

making this material are wound round with gold wire, so thickly as to conceal the silk; and the making of this gold wire is one of the most singular mechanical operations imaginable. In the first place, the refiner prepares a solid rod of silver, about an inch in thickness; he heats this rod, applies upon the surface a coating of gold-leaf, burnishes this down, applies another coating, burnishes this down, and so on, until the gold is about one-hundredth part the thickness of the silver. Then the rod is subjected to a train of processes, which brings it down to the state of a fine wire; it is passed through holes in a steel plate, lessening step by step in diameter. The gold never deserts the silver, but adheres closely to it, and shares all its mutations: it was one hundredth part the thickness of the silver at the beginning, and it maintains the same ratio to the end.

As to the thinness to which the gold-coated rod of silver can be brought, the limit depends on the delicacy of human skill; but the most wondrous example ever known was brought forward by the late Dr. Wollaston, a man of extraordinary tact in minute experiments. This is an example of a solid gold wire, without any silver. He procured a small rod of silver, bored a hole through it from end to end, and inserted in this hole the smallest gold wire he could procure; he subjected the silver to the usual wire-drawing process, until he had brought it to the finest attainable state; it was, in fact, a silver wire as fine as a hair, with a gold wire in its centre. How to isolate this gold wire was the next point: he subjected it to warm nitrous acid, by which the silver was dissolved, leaving a gold wire one thirty-thousandth of an inch in thickness—perhaps the thinnest round wire that the hand of man has yet produced. But this wire, though beyond all comparison finer than any employed in manufactures, does not approach in thinness the film of gold on the surface of the silver in gold-lace. It has been calculated that the gold on the very finest silver wire for gold-lace is not more than *one-third of one-millionth of an inch* in thickness; that is, not above one-tenth the thickness of ordinary leaf-gold! The mind gets not a little bewildered by these fractions: but we shall appreciate the matter in the following way:—Let us imagine that a sovereign could be rolled or beaten into the form of a ribbon, one inch in width, and as thin as this film; then this ribbon might form a girdle completely round the Crystal Palace, with perhaps "a little to spare."

The delicate wires of gold, or of silver, or of silver coated with gold, are applied to numerous ornamental purposes, of which abundant illustrations have been displayed at the "World's Fair." There was gold-lace, in a form fit to be applied to embroidery and other purposes, from a London firm, from our neighbours across the channel, from Belgium, from the Zollverein States, and from Russia. The woven productions, embroidered with gold-lace, were richly illustrated by the archiepiscopal vestments contributed by Belgium. The employment of gold-lace, when woven with other materials, was shown (among other examples) in the sumptuous Russian gold brocade, valued at about four guineas a yard. The exquisite *filagree-work*, from Genoa, Spain, and other countries, showed how delicately gold wire can be twisted and wrought into elegant forms; and the well-filled and well-arranged Tunis Court demonstrated how widely the use of gold thread and gold wire has extended among the wealthier denizens of northern Africa.

## Golden Trinkets and Small Wares.

These delicately-minute applications of gold are but a few among many. If we look at that delicate but perfect film of gold which covers buttons and cheap jewellery, we shall find that it is not less curious than those examples just treated. Here the gold is neither a sheet nor a wire; it is a *wash* or liquid. The buttons, when completely formed (by processes which need not be here described), are cleansed with an acid liquor; then burnished, to level all irregularities; then shaken in a vessel with a mixture of quicksilver and nitric acid; and afterwards drained from all the mercury except a thin film which adheres to each button. Next comes the gilding process; gold and mercury are melted together in an iron ladle, and the mixture is poured into cold water; it forms a paste like substance, which is squeezed in a leather bag until nearly all the quicksilver is expelled, leaving only a little combined with the gold. This amalgam of gold and mercury is mixed with nitric acid, and the buttons immersed in it; a careful application of heat drives off all the mercury from the buttons, leaving a delicate but uniform film of gold on the buttons. There are other modes of gilding buttons, but we need not stop to notice them here. Now this golden garment, which gives to a button a brilliancy nearly, if not quite, equal to that which a button of solid gold would exhibit, is so extremely thin that ten pennyworths of gold would gild a hundred coat buttons of ordinary size; and in some of the cheaper kinds of work the film is less than one two-hundred-thousandth of an inch in thickness.

As it is in buttons, so it is in cheap jewellery: the thickness of the gold is small almost beyond belief. Finger-rings, ear-rings, chains, clasps, brooches, tweezers, buckles, pencil-cases, pen-holders, bodkins, thimbles, toothpicks, bracelets, studs—all such articles *may* be of real solid gold, and sometimes are; but the Birmingham trade mostly presents them simply with a golden surface upon commoner metals; and there seems hardly any practical limit to the thinness of the gold so applied. In proportion as the age of cheapness advances, so do the manufacturers of that extraordinary town show how large a surface they can cover with a given weight of gold.

Down to about the time of Charles II. Birmingham had chiefly to do with iron and the coarser metals; but she now began to turn attention to more showy productions. William Hutton, in his quaint 'History of Birmingham,' thus notices the change which ensued:—"Though we have attended her through so immense a space, we have only seen her in infancy; comparatively small in her size, homely in person, and coarse in her dress; her ornaments wholly of iron, from her own forge. But now her growth will be amazing, her expansion rapid, perhaps not to be paralleled in history. We shall see her rise in all the beauty of youth, of grace, of elegance, and attract the notice of the commercial world. She will also add to her iron ornaments the lustre of every metal that the whole earth can produce, with all their illustrious race of compounds, heightened by fancy and garnished with jewels. She will draw from the fossil and vegetable kingdoms; press the ocean for shell, skin, and coral. She will also tax the animal for horn, bone, and ivory; and she will decorate the whole with the touches of her pencil." Hutton was perfectly right; Birmingham *has* done all this. Her beautiful steel toys and ornaments; her fine productions in stamped brass; her bronze and brass lamp furniture; her painted and polished japan and papier-maché goods; her

Britannia metal and white metal table furniture—all speak well for the industry and taste of her artizans. But as our subject here is simply *gold*, we must not wander to other departments of Birmingham industry.

The gold-trinket trade of Birmingham is carried on rather by humble tradesmen—"garret masters"—than by large manufacturers. Many a workman who has saved five or ten pounds, leaves his master, buys a little gold and other metals, and employs his wife and children as his aids in producing the veritable "Brummagem" goods, which have somewhat damaged the reputation of the town—in the eyes of those, at least, who are not familiar with the really fine productions put forth by the better firms. Let not purchasers complain if the gold-clad trinket loses its external attractions rather too soon; Birmingham, like London, can produce good goldsmithery if properly paid for it. One small garret master makes buckles, another brooches, another clasps, and so on. Buttons, it is curious to observe, are differently treated; they occupy some of the largest establishments in Birmingham. In gilt toys, mere toys, France now beats Birmingham, partly on account of the superior taste shown, and partly owing to the lowness of wages. Glass, pebble, and cameo ornaments for Birmingham cheap jewellery are mostly imported from the Continent.

The great display in Hyde Park, of which we have lately seen the close, was a cyclopædia of information on the subject of gold, as on almost all other subjects. We have had opportunities of mentioning this in many previous pages; and we will now ask the reader—if he happens to possess the "Alphabetical and Classified Index to the Official Catalogue"—to glance at the various aspects which gold there presents to his view. He will find gold and gold ore from no less than eight different countries; gold leaf, and gold-beating machines, and gold-beaters' skin, from England, and France, and Turkey, and the United States, and Australia; a series of specimens to illustrate the processes of the gold-manufacture; gold pens from half a dozen makers; engraved gold plates from Switzerland; specimens of gold-plating from France; gold lace and gold brocades, not only from English firms, but from foreigners who rejoice in the names of Starchikoff, Troeltsch, and Sapognikoff; goldsmiths' work from about sixty English firms, and from almost every other country in the world; and if we change from the word *gold* to the word *gilt*, we have still other items to add to the list.

The "curiosities" of gold in respect to the currency question may be veritable curiosities indeed; but as they launch the curiosity-hunter upon the stormy sea of politics, we gladly avail ourselves of a good excuse for keeping clear of them.

# PAPER: ITS APPLICATIONS AND ITS NOVELTIES.

THE "Fourth Estate" has paper for its domain, its scene of government, its field of action. The wonderful newspaper press, though more dependent on improvements in printing than in paper-making, is yet so largely indebted to the latter, that it becomes a problem whether the 'Times' *could* have risen to its present wonderful circulation without the invention of machine-made paper. And that which is applicable to newspapers is, in an analogous way, applicable to books and pamphlets of all kinds. The renowned "Shilling Catalogue" of the Great Exhibition, containing as it does something like three quarters of a pound of material, would probably not have been attempted in the days of hand-made paper. Not that the hand method is abandoned: far from it; but the mass of printing-paper, the 'broad sheet' which finds its way into every corner of the kingdom, and more or less into almost every country in the world, is for the most part the product of that beautiful machine which the talent of Fourdrinier and Dickinson has brought to such perfection. Besides the lowering of price and the expediting of the manufacture, the paper-machine has wrought an astonishing revolution by showing how to produce paper of any length. It matters not—a mile or a yard; the machine will make a sheet of paper such that, when coiled up, it may be as thick as a man's body. This immense increase of size may be productive of results yet unthought of.

### PAPER AND ITS PRODUCTS AT THE GREAT EXHIBITION.

Never before was seen such a display of fancy paper goods as the recent Exhibition contained. Omitting mention of the plain printing and writing papers, the paper hangings, and the papier maché, there was an assemblage of *papéterie* quite dazzling. Who does not recollect the compartment over which 'PAPER' was inscribed? The envelope-cases, the writing books, the blotting books, the tinted papers of every hue which the colour-maker could command, the scented and the enamelled papers, the opalescent and the gilt papers, the embossed and the embroidered papers, the spangled and the starred papers, the roll of paper a mile or two in length, the sheet of brown paper eight feet wide by more than four hundred in length, the sheet of pottery paper two miles and a half long, the fine tough paper made of old rope, the thin tissue paper so strong as to bear a heavy weight suspended from it, the delicately painted and colour-printed papers—all were there, decked out in most tempting array; and our foreign neighbours were not slow to contribute specimens of their skill in analogous departments of industry. Some of the specimens of bank-note paper exhibited were so astonishingly tough, that a sheet weighing only half an ounce bore a strain of 230 lbs. It was interesting, too, to see the fragment of rope which had been fished up from the poor 'Royal George,' and by the side of it a sheet of coarse paper made from some of its hempen fibres. But it was yet more instructive to study the series illustrative of the paper-manufacture, from the dirty unbleached rags to the delicately white sheet of paper.

Many visitors were, however, disappointed that there was no paper-making machine to be seen in action. When the eager eyes looked round at the mighty 'Illustrated News' machine, at the various printing-presses, at the hosiery frames, at the carding and spinning and weaving machines, at the envelope machines—when these were seen actually producing the articles for which they were intended, a wish did certainly often arise that the really beautiful operation of paper-making could be seen in process. It is true that a paper-machine of great magnitude was exhibited in the French department, and that a model of beautiful construction was contributed by Messrs. Donkin; but the former *did* not and the latter *could* not work at paper-making, and the spectators were left to wonder how so many cylinders and troughs and endless aprons can be brought to bear upon this branch of industry. It is possible that the manufacture is beset with difficulties of too formidable a character to have been surmounted in such a place; and it is at any rate certain, that much delicacy of adjustment and of temperature and of moisture has to be observed.

Although there was no actual paper-machine at work, we had nevertheless many items of information rendered by *parts* of machines. There were, for instance, Messrs. Brewer's rollers and moulds for paper-making; there was Brewer's collection of endless brass-wire cloth, wire-rollers, &c., for the same manufacture; there was Messrs. Cowan's "patent paper-pulp meter;" there were Sullivan's rollers for producing the water-mark in machine-laid paper; there was Watson's paper-pulp strainer; and there were Makin's various component parts of a paper-making machine, exhibited as specimens of manufactures in metal. And though we are not at this moment speaking of the *application* of paper, it may be well to bear in mind how varied were the illustrations of all such applications at the Exhibition. The paper-folding machines, the paper-cutting machines, the paper-ruling machine, the very curious paper-shade-making machine—all were worthy of attention, and some of them more than they received.

But, besides the English contributions, our continental neighbours did not neglect the opportunity of putting forth their best skill on the occasion. The trade bills, circulars, cards, lists, catalogues, &c. (a complete collection of which would form one of the most interesting records of the Great Exhibition), set forth the merits of the French paper as well as of other departments of manufacture. We find, for instance, in M. M. Odent's nankeen-coloured bill, an announcement of "Animal paper, incombustible, and very strong, for the preparation of cartridges for the marine;" "parchment paper, morocco'd for book covers and binding;" "nankeen paper, very combustible, for the manufacture of cigarettes;" and "white paper, sized and unsized, for printing, engraving, and copper plate." These announcements, like many others in the Exhibition, were printed in three languages; and the chief partner neglected not the opportunity to state that he had been "invested with the Order of the Legion of Honour," in 1832. Another firm, MM. Obey and Bemard, with "two silver medals," in 1844-9, announce, similarly in three languages, "violet-paper, a preservative from rust, for needle papers and envelopes;" "coloured and tinted papers, for drawings, pamphlet covers, and book-binding purposes;" "black papers, for packing cambrics, linens, &c.;" "white writing and printing papers;" "endless webs, thoroughly sized, for drawings and plans;" and "endless webs for paper hangings." Then came the firm of Bequin, whose "carton" or pasteboard manufacture is advertised and described. But the most remarkable of these French paper advertise-

ments was that put forth by the Paper Making Company of Essonne, in the department of Seine-et-Oise. The sheet containing the announcement of this firm has seven large well-executed wood-cuts, illustrative of the successive processes of paper-making. There is first a general view of the factory, with a canal, tramways, and a multitude of buildings; then comes the sorting of the rags, by women ranged in a row at tables, and having the handkerchief head-dresses which French workwomen mostly wear at their labour; next is represented the room in which the rags are being chopped up into pulp; then the bleaching process; next the actual manufacture by two complete machines; then a press-room for finishing the paper; and two other views of subsidiary character. It might be worth while for our British manufacturers to consider whether this is not a somewhat attractive mode of advertising.

This factory, we may here remark, appears to be on a very extensive scale. It was at Essonne that Louis Robert, a working paper-maker, invented the first paper-machine in 1799; but, although the English brought the invention to a practical issue in 1809, the French had no paper-machine at work till 1815; they had four in 1827, twelve in 1834, and now have upwards of two hundred. These two hundred machines work up daily about 200,000 kilogrammes (430,000 lbs.) of rags into paper, which, if formed into an endless strip five feet wide, would extend 2000 kilomètres (1250 miles). It was in 1840 that a Company (called in France a *Société Anonyme*) was formed for establishing a paper factory on the spot which had witnessed the birth of the paper-machine. The factory stands close to the Corbeil Railway, about an hour's run from Paris. It has three complete machines for making paper, and twenty-six triturating machines for making the pulp. The rag warehouse is said to contain a store of 400,000 kilogrammes (870,000 lbs.) of rags; and contiguous to this is a large building in which women spread out and sort the rags. In another building the rags are beaten to expel mechanical impurities and dust, washed to get rid of dirt and grease, teazed or torn into shreds, and bleached. The washing is effected in monster coppers, which hold three or four thousand pounds of rags. The various machines are set in motion by an abundance of motive force, supplied by six water-wheels, a turbine, and a steam-engine. The works occupy an area of nearly fifty acres; but this includes accommodation for the work-people. The mode in which these work-people are treated deserves attention. They are about three hundred in number, of whom two hundred take up their abode within the establishment, and have a garden at their disposal. The remaining hundred, who live out of the establishment, have a comfortable refectory or eating-room; there are warm baths for the gratuitous use of the operatives; a medical man calls every day and gives advice and medicine to any who need his aid; while a nursery and a primary school are established, with fires, tables, books, maps, &c., for the young children of parents engaged in the factory. There is much thoughtful kindness in all this.

But this establishment at Essonne has taken us away from the Great Exhibition. We need not, however, stop to dilate on the various productions contributed by other countries. Switzerland sent her music paper, plate paper, and wrapping paper of excellent quality; together with writing and tissue papers of various kinds. Rome, the land for artists, showed what good drawing paper she can produce. France is said to produce better thin than thick writing paper; England better thick than thin; and it is not unworthy of consideration whether the French postal system may not have some influence on the thinness of the paper made for letter-writing. Belgium, Russia, and

Holland, all showed their present degree of skill in the art, but evidently occupying a lower position than France. The Zollverein collection was very numerous; and one group was especially interesting, inasmuch as it displayed in juxtaposition specimens of the papers produced at one mill in Prussia through the long period of ninety years—thereby affording materials for tracing a progressive rise in excellence. There was a series of calico-print patterns, in the English department, which gave the same kind of instructive testimony to the chronological progress of that art.

Of the paper hangings and the stationery and the papier maché at the Exhibition, we shall speak further on.

## The Materials for Paper.

Many have been the attempts to employ other materials for paper than those customarily used in this country. Rags would seem to be cheap enough; but there may be times, and places, and circumstances, in which rags would be either unattainable or too costly. All these attempts, however, have met with singularly little success—so far, at least, as our own country is concerned. Yet it may be useful to glance at a few of the substitutes which have been proposed.

The paper of the ancients, as most readers are aware, was not properly paper at all; that is, it was not a prepared pulp cast into the form of sheets and dried. *Papyrus* is the botanical name of a certain species of plant; papyrus is the name given to the paper made from the soft cellular flower-stem of this plant; and papyrus is also the name generally given to the ancient written scrolls made of this material—just as we give the name of *tea* to a plant, to the dried leaf of the plant, to the infusion of the dried leaf, and to the meal at which this infusion is drunk. The papyrus is a very common plant in Egypt, Syria, and Abyssinia; the stem is from three to six feet high; and it was from the thin concentric coats or pellicles which surround this stem that the ancient Egyptians made their papyri or writing-papers. The mode of building up a long strip of writing-paper from such elementary materials seems to us, in our day, wofully clumsy. The narrow slips of fibre, six or eight inches long, were laid side by side and another layer pasted over them crosswise, so as to form a coherent double sheet. This sheet was pressed, dried in the sun, and polished with some hard smooth substance. Several others were pasted to it end to end, until a roll twenty or thirty feet long was formed, with only a few inches of width; and it is on such rolls or scrolls that many extremely valuable Egyptian and Greek manuscripts, still extant, are written. It is curious to trace how our words *paper* and *Bible* have been derived from this plant-stalk; from the Latin name, *papyrus*, has sprung the modern words *papier* and *paper;* while from the name for the same plant given by Herodotus, *byblos*, is supposed to have sprung *biblion*, *Bible*, and other words and names relating to books.

The Chinese—that most extraordinary 'self-contained' nation—make a filamentous kind of paper much superior to ancient papyrus; it obtains in England the name of *rice-paper;* but sufficient is now known of it to show that this is by no means a correct designation. Dr. Livingstone introduced Chinese rice-paper in England about half a century ago; it had immense favour as a material for artificial flowers, and gossips say that Princess Charlotte paid seventy guineas for a bouquet made of this material. It was many years afterwards that information was obtained concerning the mode adopted

by the Chinese in making these small but very expensive sheets of paper. There is a leguminous plant growing in China and India, the stem of which is cut into pieces eight or ten inches in length; and these are cut by the Chinese into one continuous spiral film, on the same principle as the modern mode of veneer cutting, but by the dexterous use of hand-tools. These laminæ, being spread out and pressed flat, form thin sheets, which, after being dyed and otherwise prepared, constitute the rice-paper of the Chinese.

The same ingenious people make paper of *bamboo*. The bamboo stems, when about three or four inches thick, are cut into pieces four or five inches long. These, when softened in water, are washed, cut into filaments, dried and bleached in the sun, boiled, beaten to a pulp, and made into thin sheets of paper. This is truly paper, which the former examples are not; and the art must have made a notable advance before such a method could have suggested itself.

Most nations in the early ages, and rude nations in the present, have looked rather to vegetable than to any other substances as the materials for paper. Palm-leaves, the inner bark of the elm, the maple, the beech, the plane, and the linden tree, leaves of various plants—all have been employed. But the animal kingdom has not been neglected by experimental paper-makers. We have heard of skins, and silk, and leather, and waxed tablets; while every one knows that *vellum* and *parchment*, essentially animal substances, still play a very important part as substitutes for paper. Nor have mineral substances failed to be appealed to. There is a very puzzling substance, called *asbestos*, which has extraordinary power in resisting the action of fire, and the source of which was for many years unknown in this country. Both cloth and paper have been made from it. The original material is a greenish-gray fibrous stone, found in great abundance in Corsica; and by processes of pounding and sifting, moistening and mixing, it is capable of being wrought into sheets of a kind of paper. Professor Bruckmann of Brunswick, some years ago, bethought him that it would be a good way to exhibit asbestos paper by making it up into a book; he therefore wrote a treatise on asbestos and its qualities; and printed a few copies on asbestos-paper—rough, coarse, but said to be incombustible.

Bright hopes were entertained some years ago that good paper might be made from *straw*. One of the principal tanneries in Bermondsey, called Neckinger Mills, was originally a straw-paper manufactory. It appears that the straw was cut up into pieces two or three inches in length, steeped in cold lime-water, and cut up into infinitesimal fragments in a paper-mill; the pulp thus produced was made into paper by the usual train of processes. But the enterprise failed in Bermondsey, and a second time failed at Thames Bank; the paper produced was harsh and ill-coloured. A further attempt was made to brave the difficulties; additional processes were adopted to free the straw from knots, to extract the colouring matter, to dispose it to become fibrous, to free it from mucilage and from siliceous particles, and also from the odour of many of the chemicals employed in the former processes—all means were adopted, in short, to coax it to become a good paper-making material; but these numerous processes became at length very costly, and the straw-paper was neither fine enough nor strong enough to command an adequate price. So it died a commercial death.

There is in the British Museum a remarkable book, treating of the manufacture of paper from various kinds of bark, leaves, and fibres, and printed on leaves of paper made from the various substances described. It is a

curiosity, and a useful one, in so far as it bears testimony to the capabilities of sundry materials; but it must honestly be confessed that the specimens would not pass muster very satisfactorily if tried by the ordinary tests in respect to fineness, colour, and smoothness.

Rags, however—the fragments of worn-out linen and cotton garments—are the great store house of material for paper-making. There are abundant reasons for thinking that the Chinese, who were the first to make paper from pulp of any kind, were also the first who converted old garments into new sheets of paper. The art travelled somehow from China to Samarcand, whence the Saracens transferred it to Spain; and from Spain it spread throughout Europe. One Tate is said to have been the first to practise the art and mystery of paper-making in England, at a mill which he established in Hertfordshire in the early part of the sixteenth century. The next we hear of was a German, who stationed himself at Dartford in 1588, and who was knighted by Queen Elizabeth. In the time of Fuller the manufacture had made but little progress in this country, the chief supply being obtained from abroad. He quaintly tells us that "Paper participates in some sort of the character of the country which makes it; the Venetian being neat, subtle, and court-like; the French light, slight, and slender; and the Dutch thick, corpulent, and gross, sucking up the ink with the sponginess thereof."

Sweynheim and Pannartz, two Germans who settled at Rome soon after the invention of printing, and who were the first to introduce the art in that city, printed many works, but did not find an adequate sale for them; and in a petition which they presented to the Pope, they drew his Holiness's attention to the difficulty of obtaining rags; they said "If you peruse the catalogue of the works printed by us, you will admire how and where we could procure a sufficient quantity of paper, or even rags, for such a number of volumes."

Many a reader may have marvelled, as these old printers thought the Pope might marvel, whence or how the supply of rags for paper-making can be kept up. If any one country were depended on, the supply would certainly fail; but by appealing to the rag-bag of *every* country, a continuous store is maintained. The Hungarian shepherd's frock or tunic-shirt, the blue shirt of a weather-beaten sailor in the Mediterranean,—all such garments, as well as those of finer texture, are welcome. The material for a sheet of paper may, as has been remarked, "have constituted the coarse covering of the flock bed of the farmer of Saxony; or once looked bright in the damask table-cloth of the burgher of Hamburgh; or may have been swept, new and unworn, out of the vast collection of the shreds and patches, the fustian and buckram, of a London tailor; or may have accompanied every revolution of a fashionable coat in the shape of lining—having travelled from St. James's to St. Giles's, from Bond Street to Monmouth Street, from Rag Fair to the Dublin Liberty—till man disowned the vesture, and the kennel-sweeper claimed its miserable remains." These "kennel-sweepers" pick up a considerable quantity of linen and cotton fragments—not so much, probably, now as in past times, on account of the more frequent and complete sweeping of the streets. In Paris the bone-grubbers or *chiffoniers* form quite a fraternity, who have not failed to play their part in the numerous *émeutes* which have disturbed that excitable capital.

## The Manufacturing Processes.

To detail formally the various operations in the manufacture of paper is no part of the present object; but a glance may be taken sufficient to show the relations between the several stages of process.

The paper-mills are mostly in pretty valleys where abundance of clean water can be obtained—water to turn the machinery, and water to make the pulp. Many a paper-mill can be seen by railway travellers as they whirl along—in Hertfordshire, in Kent, in Somersetshire, and elsewhere. For the most part good water-power is the desideratum; but in some cases a mill is established near the spot where a particular kind of paper is much demanded. Messrs. Fourdrinier, for instance, have a mill in Staffordshire, where they make the thin but tough paper so largely used in printing blue and white earthenware.

Wherever it may be, near or distant from London (there is no paper-mill *in* London), the first care of the manufacturer is his rags. From Trieste, from Leghorn, from Hamburgh, from Rostock, and from other ports, the rags of various countries are brought to England; and the capabilities of each have to be determined. English housewives have the reputation of being very cleanly; those of Italy are far otherwise; and the linen and cotton rags afford striking proof of this difference. Many continental countries positively prohibit the exportation of rags at all, and we have therefore to be content with such as are accessible. The rags are packed in bags of three or four hundredweights each; and these, when opened at the mill, are placed under the care of women, whose duty it is to sort them, to shake out the loose dust, to cut them into moderately small pieces, and to separate the seams and hems from the other pieces. A keen eye and a dexterous hand are required in this preliminary operation.

Then comes the truly chemical process by which the dingy, dirty, discoloured rags are brought as purely white as a delicate sheet of paper. Some of the English rags are so clean that they require no bleaching; but the whitey-brown, or worse than whitey-brown, rags of other countries have to pass through an ordeal in which chlorine exhibits its wonders. They are placed in a close chest, chlorine is admitted to them through a pipe, and in a few hours every vestige of colour is removed; a strong chlorine odour is imparted, it is true, but a good washing removes this.

The boiling, and the washing, and the bleaching differ in degree according to the state of the rags; but the comminution, the dissection, the severance into infinitesimal fragments, is required alike for all. In one machine the rags are drawn between sharp knives on a roller and sharp knives on a plane, and are unmistakably bruised by the transit; while in another machine, which works more rapidly, and has its knife-edges more closely together, they are so thoroughly tossed about and cut up, as to form, with the water in which they are immersed, a smooth cream-like pulp. *Blotting* paper derives its peculiar property from having no size in it; printing and writing paper are always sized; and some kinds receive their quota of size when in the state of pulp.

From this pulp, kept agitated in a vessel, sheets of paper are made. The dexterous manipulations of paper-makers on the hand method are very remarkable. The pulp is transferred to a steam-heated vat, where it is kept warm and well agitated. The workman has two *moulds*, consisting of slight wooden frames covered with wire-gauze, and having moveable *deckels* or ledges. The length and width of the deckel determine the size of the sheet to be made. The vat-man dips a mould into the pulp, takes up as much as his

experience tells him will make one sheet, places it on one side in the hands of another workman called the *coucher*, takes off the deckel, places this deckel on another mould, and makes another dip into the vat. The coucher neatly turns over the mould, and empties the thin layer of pulp upon a piece of flannel or felt, through which the moisture may filter or drain. Thus the two men proceed—the vat-man supplying new sheets as fast as the coucher can build up a pile of felts to receive them; and the coucher liberating the moulds as quickly as the vat-man requires them. When one or two hundred sheets, with felts interposed, are thus accumulated into a pile, the pile is heavily pressed; this gives the film of pulp sufficient coherence to maintain its form unsupported; the felts are removed, the sheets are placed one on another, and a second pressure flattens them, and to some extent smooths them. They are now essentially sheets of paper; and these sheets, after drying, sizing, drying again, pressing, examining, and other processes, are finally made up into quires.

But how shall we describe the *paper machine?* It is one of the most complete of modern inventions—so many processes does the machine successively perform in a short space of time. The parts of the machine appear very numerous to a spectator, and the machine itself one of great length; but when we consider what it has to do, we cease to marvel at all this. A creamy pulp flows into a machine at one end; the same pulp comes out in the form of made and *dried* paper at the other, in the course of two minutes!

How the pulp changes its form and state is wonderful to look at. It flows from a huge vessel or chest into a vat; it flows from the vat upon a narrow wire frame called a sifter; it flows through this sifter upon a flat surface, and then falls over a ledge in a quiet stream equal in width to the paper about being made. It falls upon a flat surface of wire-gauze, where it is shaken from side to side, drained of much of its moisture, and converted into something like a very wet sheet of spongy paper. This sheet is pressed by a wire cylinder and by a felted roller; it passes on an endless cloth, and becomes further drained; it is seized between rollers and squeezed; it is further drained and further squeezed by other cloths and other rollers; it passes over a heated cylinder, then over another still more heated, and then over a third heated to a yet higher temperature; it is pressed, too, between whiles; and it reaches the remote end of the machine in the state of dry and smooth paper. And this is not simply a quadrangular sheet, having a definite number of inches in length—it is an *endless web*. While one portion of the pulp is a creamy liquid, another near it is a thin wet layer, another a wet but coherent film, another a partially dried film, and so on; all the portions alike reach the last cylinder, and all are alike perfect paper when they reach it. The paper is wound on a reel as fast as it is made; and there may be thus formed a roll miles in length. In the earlier machines the roll of paper was removed, and cut into sheets by a separate machine; but modern ingenuity has shown how to make the paper-machine cut the paper itself. Some of the modern machines, too, have an arrangement by which an air-pump sucks away the moisture from the pulp, and converts it into a coherent film with extraordinary quickness.

Every year brings out its patents for new improvements in paper-making. Sometimes they relate to mixing the pulp; sometimes to regulating its flow; sometimes to the formation of 'water marks' by wire cylinders; while the drying, or the polishing, or the cutting are the subjects of others.

The master-difficulties were surmounted many years ago, when Fourdrinier showed how to produce a long roll of well-made paper; all the subsequent improvements have related to minor points.

As to the paper itself, its varieties are too well known to need much description. The 'Bath,' the 'post,' the 'laid,' the 'foolscap,' the 'yellow wove,' the 'blue wove,' the 'satin,' the 'cream,' the 'ivory'—all these designations of writing paper, though partly unmeaning, and partly exaggerated, relate either to the existence or non-existence of lines in the paper (produced by wire-web cloth), or to some particular modes of finishing. Then printing papers differ in their thickness, their fineness of surface, and their size. The brown, whitey-brown, and wrapping papers of all kinds form another large class, in which coarse and strong fibres take the place of white and delicate. Next come the varied group of coloured papers, some of which receive their colour in the pulp, while others are painted with or steeped in colour afterwards. Another large supply is taken off by paper-stainers, whose wall-decorations require paper in large surfaces but of inferior quality.

But we shall be better able to understand the ever-varied forms in which paper is presented to our notice, if we glance at some of the numerous subsidiary manufactures which depend upon its use as a material. And first let us see what a celebrated London firm has to show us.

### De la Rue's Manufactures.

Of all our manufacturing establishments, that of Messrs. De la Rue is, per haps, the one wherein paper is made to undergo the greatest variety of artistic transformations. Paper-stainers in one direction, and printers in another, doubtless cover a larger surface of paper with the results of their handiwork; but where paper, to the extent of tens of thousands of reams annually, is converted by four or five hundred workpeople into dainty envelopes, note-paper, cards, coloured papers, and other tasteful productions, the diversities exhibited must be very notable.

In few, if any, departments of industry has the union of *machinery* and *fine art* been more observable than in the branches of the paper trade now under notice. A shilling packet of envelopes, or a half-crown's worth of *papéterie*, or the coloured labels and wrappers for piece goods in the manufacturing districts, are dependent both on the one and the other. Even the artistic features themselves are largely indebted to machinery for their development. The artist and the mechanic are pulling at different strings; but the strings meet at one point, and work conjointly towards one object.

Without any formal description of the factory or its manufactures, let us jot down a few of the notable "curiosities" in the application of paper at De la Rue's.

And, first, let us summon a pack of cards before us. Never, perhaps, did fashion cling to absurdities more oddly than in respect to these instruments of play. The fine staring figures which appear on the wrappers of the several packs are pretty nearly the same 'Moguls,' and 'Harrys,' and 'Highlanders,' that they used to be, and still give names to different qualities of cards. This may be forgiven; but the outrageous 'court cards' are surpassing strange. Messrs. De la Rue have more than once attempted to beat into the heads of card-players the simple truth, that kings and queens and knaves may be the same efficient "trumps" as before, and yet have something like artistic grace about them. But no; the old whist-players will not reform, and humbler players cannot take the lead; so we have the court cards dressed nearly as of yore. The queens are still wrapped up in a costume which equally defies the feminine and the "Bloomer" systems; the king of spades

still thrusts out his leg in a way most independent of all anatomy; and the knaves, in their blue and yellow hair, their thick knees and small ankles, their coats of many colours, and their indescribable flat hats, still continue to form the most extraordinary knavish party ever known. And, as we live in an age of alleged utilitarianism, we have not scrupled to double the heads of these court personages in order to view them either end uppermost; each one has a head where his feet should be; each is his own antipodes; each is a Siamese couple, joined in a most original manner.

But if card-players have refused to listen to reforms in this matter, they have been more pliant in respect to other improvements; they have consented to 'coloured backs,' and to oil-printed faces. Some card-makers still employ the old method of water-colours; but the modern system, introduced by Messrs. De la Rue, produces a coloured impression much more lasting. So 'self-contained' is this establishment, that the stamps and plates for printing cards, the dies for embossing fancy stationery, and moulds and devices of every description, are made and engraved on the premises; nay, even the various machines, of which we shall presently have to speak, are similarly managed.

The colouring of paper is no trifling matter in an establishment such as the one now under notice. There is a colour-grinding mill; there is a laboratory of chemicals; and there is a whole army of bottles and boxes and drawers filled with drugs and colours and oils. These colours, when mixed to a proper consistency, are applied to large sheets of paper; for the reader must know that the colour is not applied to the cards themselves. A sheet of paper, large enough (say) for forty cards, is printed at a press, with ink or print of one colour, from an engraved plate of copper or brass. One plate is for spades, another for hearts, and so on. Some packs, for players of weak sight, have four different colours for the four suits; but the old system of two black suits and two red is mostly acted on. In respect to the court cards, they require as many different engraved plates, and as many successive processes of printing, as there are colours. The coloured backs, too, are printed in a similar way; for these are not merely coloured, but printed also. Sheets of paper are coloured (by a process which we may find an opportunity to notice presently) of almost every imaginable tint; and one of these being selected, it is printed with any device and in any colour which may be chosen.

Meanwhile other hands have been labouring to fashion the material from which the cards are to be made. A card is built up of numerous layers of paper; and the paste-brush is an important agent in making it, Sheets and quires and reams of paper are selected, of such quality as may meet the object in view; and a workman—with these sheets on one side of him, and an abundant supply of paste on another—proceeds to paste these sheets two and two together. The pasters do nothing else; and the paste-makers have to provide hundreds of gallons *weekly*. The pasted couples are piled in heaps, the heaps are placed in hydraulic presses, and a good squeeze effectually unites each pair. When this pasting has been carried on till the cardboard is thick enough, the printed face is pasted on, and also the coloured back (if any).

The finishing processes to which the cards are subjected are more numerous than would generally be supposed. The boards, each the size of forty cards, are dried in steam-heated vaults; then equalized in surface by a kind of revolving scratching brush; then passed between rollers, of which one is made in a remarkable way by discs of paper placed face to face; then rolled again: and then subjected to enormous pressure to flatten them. All this time

the forty cards form one piece of cardboard, but now the process of separation ensues; a cutting machine, of simple but effective action, cuts the boards first into strips and then into cards; and thus some forty thousand a day can be fashioned by one man. The sorters then examine every card singly; and according as it has one or other of three degrees of faultiness (or perhaps we should say faultlessness, so admirably are they now made) each card takes rank as a 'Mogul,' a 'Harry,' or a 'Highlander.'

The paper roller just mentioned is one of the singular modern applications of this material. Ten or twelve thousand circular pieces of paper have a hole formed in the centre, through which a spindle runs, and they are pressed together with such enormous force that, when turned in a lathe, they form a cylindrical roller of singular density, evenness, and smoothness. A peculiar degree of slipperiness—very important for the 'shuffling' process—is given to one surface of each card by the pressure of this paper cylinder; for it is a curious fact, that in order to make cards shuffle and deal well, it is found necessary to give the faces a slightly different kind and degree of smoothness from the back.

And now, laying aside the thousands of packs of cards thus made at this establishment, we may talk awhile of the *coloured papers* made for so many fanciful purposes. In the show-room devoted to such matters, there is a blazing star of a hundred and thirty-two radii, formed of strips of paper, no two of which present the same colour—this represents the chromatic power at the command of the manufacturers; whether we take Newton's system of seven colours, or Brewster's of three, here we have them all, and all the gradations produced by varying combinations of them: the blending, the harmony, the contrast, the complement of colours, are well shown. All such papers are coloured on one surface only. The pigment is mixed to the desired tint and consistency; and a colour machine of very peculiar construction applies an even layer over the surface, feeding itself with paper and with paint as it works. The long strip—some hundreds of yards in length—travels onwards over the platform, submits itself patiently to the paint-brush, then passes over heated plates, and leaves the machine coloured and dried. It is one of those operations in which nothing less than a very large demand could warrant the use of a machine; but in which, the demand being created, machinery at once finds itself at home. The *glazed* and *varnished* papers, too, receive their acquirements in a similar way. The *enamelled* cards are examples of those productions in which a wash is so applied to card or paper as nearly to equal real enamel in smoothness, whiteness, and delicacy of appearance.

The old-fashioned *marbled paper*, still extensively used by bookbinders, is made in a remarkable way. A viscid kind of paint-liquid is prepared, on the surface of which different colours are intermingled; and the sheet of paper is dexterously laid on this surface, from which it draws up a film of the intermingled colours. Now Messrs. De la Rue have recently applied a totally different colouring theory to the production of papers singular in their novelty and beauty. The specimens at the Great Exhibition were placed in a somewhat dark corner, and were not so well known as the ever-popular 'Envelope Machine.' These papers are *iridescent*, or *opalescent*, or *nacreous*—that is, they exhibit the ever-varying hues of mother-o'-pearl or of opal. Looking at them from one point, they display all the tints of the rainbow; change the point of view, and every little spot displays a different tint from that which before distinguished it. Most delicate and graceful is the result. The fundamental tint of the

paper may be white, or black, or any other at choice; and yet these pearly hues shall present themselves. A beautiful principle in optics is here brought into play; *no colour is employed* to produce the opalescence! The soap-bubble exhibits its beautiful hues, although the water is nearly colourless; and so likewise it is in the present case. When a film of any transparent substance is so thin as a twenty-thousandth or a fifty-thousandth part of one inch, there occurs what philosophers call an 'interference of light' at the two surfaces, which produces colour; and this colour depends upon the thickness of the film and the angle at which it is viewed. This law governs the production of colour in some of the most beautiful of natural objects; and Messrs. De la Rue have skilfully brought it to bear upon paper. Each sheet of paper is covered, by a careful process of dipping, with an exceedingly thin film of a peculiar varnish; the process and the varnish being so chosen as to produce opalescence or iridescence. It would be difficult to predict all the uses to which so delicately-adorned a material might be applied; for book covers, for wall decorations, for paper ornaments—indeed, for almost all the purposes to which painted, stained, marbled, stamped, or embossed paper is adapted, this new material may be fitting. Already have the inventors begun to produce many curious ornamental articles by its means.

The *embossed* paper, and the better kind of *colour-printed* paper, call for an astonishing amount of artistic skill at such an establishment as Messrs. De la Rue's. Designers are always at work on new patterns; sometimes following, but more frequently leading the taste of the public. Be it a fanciful wrapper for a piece of linen or of muslin, or a bouquet-holder, or a cover for a paper box, or a *papéterie*-case, or a wedding-card, or a mourning envelope, there is a perpetual infusion of novelty in design or colour, or both. The embossing of paper, or the production of *cameo* and *intaglio* effects, is one of the greatest sources of beauty. If a portion of the surface is to be so embossed, a die is engraved, and a powerful press employed; but if the whole surface is to have a design, the paper is passed between copper rollers, one of which is engraved. Thus are produced the endless variety of embossed or 'lace,' or 'morocco,' or other papers having a raised device. Some of the works produced by Messrs. Dobbs and by Messrs. De la Rue in this department of manufacture are really works of art.

Nor are painting and colour less sedulously attended to. De la Rue's books of patterns, in which the designs are arranged and tabulated, form quite a rich assemblage of artistic taste, and illustrate the gradual means by which grace and beauty are becoming familiarised to all; for it is to the cheap as well as the costly articles that these designs are applied. The delicate-tinted note-paper, now so much used by ladies, was among the introductions of this firm; but, on the other hand, the cheap and neat envelope-boxes, and paper-cases, and writing-cases, owe no little to the ingenuity of the same inventors.

"Five quires for a shilling," is a labelling that now meets the eye in every town. Thanks to the firm who first adopted this mode of breaking down a ream of paper into convenient parcels, and tying up these parcels into nicely-wrappered shilling's-worths. The paper may be letter-paper or note-paper; the quires may be three or four or five in number; the price may be greater or smaller according to quality; but the principle was, to establish something between the quire and the ream, and to throw into this something a little modicum of 'fine art.' Paper itself is not made by the firm now under notice; but paper is made *for* them, according to patterns designed by themselves; and thus we have 'Queen's,' 'Albert,' 'Alhambra,' 'Damask,' 'Eliza-

bethan,' 'Wave,' 'Watered,' and other note-paper, according to the watermark which is introduced into it, or other characteristics imparted to it. Thus, too, in note-paper intended for bridal or for mourning occasions, the paper itself is procured elsewhere, but the symbols, and the edging, and the stamping are the handiwork of this or some similar firm. Nothing can exceed the delicacy of some of these fancy articles. The bridal cards, and note-paper, and envelopes, are rich in hymeneal symbols, not merely embossed by a press, but in some cases picked out in silver; and the sombre enrichments of mourning stationery are not less redolent of the cypress, the willow, and analogous emblems. Bouquet-holders, too, have often gold or silver taking part in the embossed design. In such cases a pattern is printed with gold-size instead of colour, gold leaf is applied, which adheres only to the printed part; and the embossing is effected afterwards. In commoner work the gold is a "delusion and a snare;" it is a powder of oxidized brass, sprinkled over the moist gold-size.

The French give the name of *papêterie* to stationery in general, and *papêtière* to a case containing stationery; and these *papêtières*, ranging in price from one shilling to two guineas, and mostly made of paper and card, are among the most curious examples of Messrs. De la Rue's productions, so infinitely varied is the taste which they display.

The little bits of card which are used in millions as 'railway tickets'—those passports for the national highways—are mostly prepared up to a certain stage by Messrs. De la Rue. The cardboard is made, coloured in one or two tints, printed in black or in colour with certain devices, and cut up into separate cards; these cards are transmitted to the respective companies, in whose offices they are further printed and registered by the machines noticed in an earlier number of this series. These small coarse cards are among the humbler examples of their class; but *visiting* cards are a production on which great taste and delicacy are now bestowed. In addition to the 'At Home' cards, and others of a similar character, embossed by stamping, the lustrous *enamelled* card is a notable modern invention.

## Penny-Post Stationery.

Rowland Hill's Penny-Post system has done more to advance the manufacture of stationery than any other single cause whatever. The letter-paper, the note-paper, the envelopes, the postage-labels, all bear witness to this fact. The department of Messrs. De la Rue's establishment appropriated to envelope-making is quite astounding for its magnitude; and this may be a convenient place to throw together a few notices both of the envelope and the postage-stamp systems.

How many envelopes the world produces, how many London produces, annually, we know not; but Messrs. De la Rue turn out about a hundred millions in a year. If we go into some of the rooms, we see fifty or sixty women and girls folding and gumming envelopes with a celerity which the eye can scarcely follow; go into another, and we have before us a dozen machines doing the same work still more expeditiously. Surely the world has become a world of letter-writers, else whither can the envelopes go? Here, as in other matters, excellence and cheapness advance together, when the demand increases. There are London shops at which envelopes, made of really serviceable paper, and having gummed and embossed tips, can be purchased at sixpence per hundred, sorted into four sizes, and bound with fanciful gilt and coloured

bandages. With envelopes at sixpence a hundred, and steel pens at sixpence per gross, the 'complete letter-writer' has indeed many temptations held out to him.

The Government envelopes are made with a thread or two running through them; these threads are introduced into the pulp during the making of the paper; but ordinary envelopes have no such additions. The large sheets of paper, pressed and rolled to give them smoothness, and packed into heaps, are *guillotined* into oblong strips; and these strips, piled in heaps of four or five hundred each, are cut into diamond-shaped pieces—or, for more fanciful shapes, they are cut at once by a curved cutting-stamp. If we follow these pieces into the envelope-room, we there see a striking example of the tact which constant employment at one occupation gives. The more common envelopes are made by machine, but the less-used sizes are still made by hand; and so fast do the fingers of these hand-workers move, that each woman or girl can make two or three thousand in a day! No description can tell adequately how this is done. In the first two folds several papers are done at once, with nothing but the eye to guide the hand; in the last two folds each paper is treated separately. And then the application of the gum, with the fixing down of three out of the four lappets, is a perfect marvel of quickness.

But the machine-made envelopes are those which have more effectually brought down the price and brought up the quality; every envelope is, to a hair's breadth, the same size as its fellow, and like it in every particular. Rattling and clattering and humming away, there are in the envelope-room thirteen of those machines, one of which was seen by so many million eyes in the western nave of the Great Exhibition. This machine, invented conjointly by Mr. Edwin Hill and Mr. Warren De la Rue, is an exceedingly beautiful contrivance. It performs many successive operations with unerring accuracy. A boy places a diamond-shaped piece of paper on a little platform; a sort of plunger descends, and forces the central part of the paper into an oblong quadrangular cavity; the four corners stand erect, and these are successively flattened by four levers, fingers, or thumbs (whichever we may term them), whereby the envelope form is given. And when all is done, two India-rubber fingers lightly touch the envelope, and delicately draw it aside, to make ready for another. These fingers are quite a refinement of ingenuity; they are small metallic cylinders, with bits of India-rubber at the lower ends; these finger-tips have just enough of the glutinous or sticky quality to adhere slightly to the paper on which they are pressed, and to draw it away from its place in the machine. But while these processes have been going on, there is another series also in operation, to effect the gumming or fastening. There is a supply of gum, which spreads itself over an endless apron or blanket; and an artificial arm takes a supply of gum from this blanket, to apply it to the envelope. All these movements are so nicely adjusted, that the gum is applied in its proper place just before the flap of the envelope is folded down. As fast as the envelopes are made, they range themselves on an inclined plane, with the precision of well-drilled soldiers, and slide up into a box prepared for their reception. Thus does each machine make its sixty envelopes in a minute.

The very elegant envelope-machine invented by M. Rémond, and exhibited by Messrs. Waterlow at the Great Exhibition, in addition to much novelty in the folding and gumming apparatus, has a singular contrivance for feeding itself with paper. The diamond-shaped pieces are placed in a heap by the

side of the machine, a hollow tube thrusts itself forward and rests upon the topmost paper, the air is drawn from the tube by a tiny air-pump, and the topmost paper clings by atmospheric pressure to two minute holes on the lower surface of the tube; the tube withdraws itself, drops the paper exactly in the spot where the folding and gumming mechanism is placed, and travels forth in search of another. The machine requires the aid of an attendant to remove and press the envelope; while De la Rue's requires similar aid to place the paper; nevertheless, the tube of the one machine, and the elastic fingers of the other, are among the prettiest novelties of this mechanical age.

Generally speaking, each of De la Rue's machines can make about as many envelopes as nine expert women, or about twenty-five thousand per day. And yet more women and girls are employed in making envelopes than at any former period; so true is it that machinery frequently increases the field for hand-labour, by creating new branches of manufacture.

As learned names are now given to various other products, so we may here notice a recent invention by a London manufacturer, which rejoices in the name of the *Polychrist Envelope.* It is a sheet of note-paper and an envelope contained in one—cut, in fact, out of a larger sheet, in such a way that the sheet forms its own envelope. The idea is not without its merit; for the legal identification of a letter may often be facilitated by having the post-mark on the letter itself, instead of on a separate envelope.

The envelopes sold by ordinary shopkeepers now far outnumber those which have the oval Government medallion upon them; but still these latter are produced in millions annually, and the preparation of them constitutes a singular branch of Somerset House responsibility. Mr. Edwin Hill is at the head of that department of the Stamp Office which has control over postage-stamps; and he has under his management quite a large manufacturing establishment. He does not make the envelopes themselves, nor the penny and twopenny postage-stamps, but he stamps those envelopes which are sold by the Government, and makes the tenpenny and shilling postage-stamps used for foreign letters. In a certain apartment at Somerset House there are machines daily employed in stamping envelopes. The oval medallion stamp is carefully engraved on a hard steel die; and the machines are skilfully adjusted so as to ink their own dies with pink colour, and bring the dies down upon the paper. The papers are sent to Somerset House, cut to the proper size and shape for envelopes; a boy takes a handful of these, spreads them out, and feeds them into the machine at the rate of sixty in a minute; the machine inks its own die at this rate of speed (once in a second), and stamps after each inking. How wonderful must be the precision to effect all this! Four things have to be done within a second: a boy places a piece of paper, the colour-rollers ink the die, the die presses on the paper, and another boy removes the paper. The two boys are virtually parts of the machine itself.

We have said that the higher-priced postage stamps are made at Somerset House; but the system is more strikingly illustrated by the penny and twopenny stamps. There is a house in Fleet Street, very unpretending externally, where postage-stamps are made annually to the value of something like a million sterling—that is, post-office value, not intrinsic value. Messrs. Bacon and Petch have a contract for producing the penny and twopenny postage-stamps. The contract (lately renewed) was made in 1843, and shows how large a matter a penny stamp becomes when it is multiplied by millions. The contractors provide steel plates, each large enough for 240 'Queen's heads;' they engrave the plates with the well-known device (the head being a

reduced copy from Wyon's 'City Medal'); they renew the plates as fast as they become worn out; they provide all the dies, presses, and machines necessary; they make the blue and red inks, and the adhesive composition, according to recipes approved by Government; they receive paper from the Government, print sheets of stamps on this paper, and gum the backs of the sheets so printed: and they do all this in buildings or rooms approved by the Stamp Office, and to which the Government officers have at all times free access. For these services, the contractors agreed to receive $6\frac{1}{2}$*d.*, $6\frac{1}{4}$*d.*, or 6*d.* per 1000 stamps, according as the number in any one quarter of a year amounts to less than thirty millions, from thirty to thirty-two millions, or more than thirty-two millions. Great as these numbers appear, they have gradually come to be far exceeded, for they are now something like sixty millions quarterly!

But the largeness of this (apparently) small subject is perhaps still better illustrated by a project to facilitate the tearing or cutting of postage stamps. Conceive an inventor and the Government quarrelling whether 600*l.* or something much larger should be given for such a contrivance! The whole matter, as given in a recent parliamentary paper, is curious, and teaches us how formal and wearisome Government offices are in their official correspondence.

In 1847 Mr. Archer proposed to the Postmaster-General the use of a machine which would make a number of little perforations round the border of each stamp in a sheet, to facilitate their separation without the use of scissors. He adduced many advantages which the public and the postmasters would derive from it.* The Postmaster-General sent the matter to the Stamp Office for consideration, with a commendatory notice from some of the officials. Then Mr. Archer made an offer to the Stamp Office, in respect to it; and then the Stamp Office referred it to the Treasury. The year 1847 was now at an end, and 1848 commenced another series of tripartite official correspondence. The Treasury assented to a trial; and the Stamp Office caused the machine to be worked by their label-stamp contractors. The trials were carried on; the perforations were made by rollers—then by a fly-press—and then by a third method, to get over minor difficulties; and the years 1848 and 1849 were brought to an end before the machine was finally rendered effective. Then came the question of remuneration—managed thus. Mr. Archer applied to the Treasury; the Treasury applied to the Stamp Office; the Stamp Office made a suggestion, and referred it to the Post Office; the Post Office slightly modified the suggestion, and returned it to the Stamp Office. Mr. Archer applied to the Post Office for better terms, but the Post Office referred him to the Treasury. Mr. Archer then applied to the Treasury, and the Treasury referred him to the Stamp Office and to the Post Office; the two Boards conferred; and the Post Office recommended the Stamp Office to raise the terms a little: the Stamp Office agreed, and wrote to the Treasury thereupon; the Treasury told the Post Office that terms rather more liberal would be justifiable: the Post Office agreed, and wrote to Mr. Archer. Mr. Archer finally rejected the offer, after a battledore-and-shuttlecock game which had lasted twenty months in respect to remuneration, and fifty months in respect to the invention itself. Mr. Archer then made a tender for the whole manufacture of postage-stamps, including engraving, printing, and gumming as well as perforating; but the former contractors obtained a new contract, at the reduced terms of 5*d.* per thousand; and the perforating machines are still the unused property of the inventor. When the Government *do* become shopkeepers or manufacturers, they are remarkably 'slow'—whether we use this word in its old-fashioned or its new-fashioned meaning.

Taking our leave now of the dainty devices which adorn the lady's escritoire, and the wonderfully cheap but good stationery which the Penny Post has done so much to render familiar to us, we may turn our attention to another interesting application of paper.

## Papier Maché and Carton Pierre.

The very pretty and useful material which bears the name of *Papier Maché* does not always deserve that name. The brilliant display which Messrs. Jennens and Bettridge, and other manufacturers, made at the Great Exhibition ought to have been designated by some more significant and correct name; it is *pasted* paper and *moulded* paper, but not *mashed* or *pulp* paper, as the French name *maché* indicates. There are two distinct branches of industry here involved, which we must separate in order to speak of the notabilities of each.

And first for the real, the true papier maché, that which was introduced about twenty-five years ago, and from which Mr. Bielefeld produces such a wondrous variety of decorative ornaments. This is almost entirely paper; there may be a small percentage of other material to impart certain minor qualities, but it is essentially paper. And if we enquire what kind of paper is thus used, we find that it is any and every kind. All is "fish that comes to this net." Nothing is refused, nothing laid aside, whether linen or cotton or hemp be the fibre from which the paper was originally made: all is available, whether it be black or white, bleached or unbleached, plain or figured; whether it be fine as 'extra satin wove,' or coarse as tough wrapping paper; whether in large sheets or small fragments; whether new and unused, or old and worn;—all will be welcome to the *maché* vat. Of course, in a practical point of view, where all kinds are useful, the manufacturers look about them for cheap miscellaneous lots, instead of appealing to the bran new stock of a wholesale stationer. Bankers have sometimes tons' weight of old account books by them, which have ceased to be of use, but which they are unwilling to place in the hands of the trunk-maker or the butterman, on account of the private transactions to which the writing on the pages of such books relate; and as it is a task of no little difficulty and danger to burn these books, the bankers are glad to find a receptacle for them in the vat of the papier-maché manufacturer, under a pledge that they shall really and promptly be so used, without exposure to public gaze. Thus the banker may perchance see the relievo decorations of his own drawing-room made from his own old account books; a ledger may find a new home as part of a cornice, or a cash-book as a frame for a looking-glass, or a day-book as a ceiling ornament. Nay, these transformations may extend wider; for in years gone by, the banker's old shirt may have been transferred to the rag-bag, and thence to the paper-mill, and thence to the account-book maker, and thence to the bank, and thence to the papier-maché factory, and thence to the drawing-room of the banker's residence—where his admiring gaze may rest upon a graceful ornament, some fibres of which once clothed his own back.

The cuttings of paper, produced by the principal applications of that material, form a very large portion of the supply whence papier maché is made. Bookbinders, pasteboard-makers, envelope-makers, account-book and pocket-book-makers, printsellers, paper-hangers, all accumulate heaps of shreds and cuttings; and the papier-maché vat may receive them all, unless better prices can be obtained elsewhere. Whatever may be the source whence the supply is obtained, it is certain that paper has now reached that commercial point

which gold and silver reached long ago—that is, none need be wasted, for a market can be found for all the odds and ends.

The kind of papier maché which is now under notice is a paste-like mass formed of paper-pulp, and pressed in moulds to any desired form. Mr. Bielefeld, the leading manufacturer in this branch, has an establishment in the country where water power can be commanded, and where machines, moved by this power, bring the paper to the required state. The paper, be it of what kind it may, or of as many different kinds as it may, is moistened, and chopped, and minced, and routed about until it becomes a perfectly homogeneous pasty mass, or rather a mass having a consistency like that of dough or of putty. A trifling portion of other substances is, as we have said, introduced, but not sufficient to change the general character of the mass as a paper substance. Then comes the moulding or pressing. The material is too thick to be poured into a mould like plaster of Paris, or like molten metal; it is pressed into flattish moulds, like clay, or composition, or gutta percha. A piece is cut off, about enough for the article to be made, it is pressed well into the mould, a counter-mould is placed upon it, and the force of a powerful press is brought to bear upon it, so as to drive the material into every minute crevice of the mould.

And here we come to the artistic department of such a manufacture as this. To command anything like a leading position in decorative art, there must be an untiring attention to new designs, new artistic ideas, new combinations of form, and colour, and material. Hence, in such an establishment as the one now under notice, the moulds (made in metal from plaster models) are constantly increasing in number and value; they accumulate not merely by hundredweights, but by tons; the designer, the carver of wood moulds, the engraver or sinker of metal moulds, are all adding to the store. It may be that a new design does not 'take' sufficiently to pay the expense even of making the mould, but this may be counterbalanced by another which has a long run, and by degrees an extensive manufacturer becomes able to strike a balance, to establish an average which shall determine the *probable* returns to be expected from each new mould. Among our large establishments, where mechanical skill and fine art meet hand in hand, those which produce the most continuous run of new designs are those which generally rise to the uppermost place; and it is here that the artistic education of the artizan becomes a matter not merely of individual but of national importance.

The articles made of this material are chiefly architectural ornaments for interior use, such as ceiling ornaments, cornices, and so forth; but they are becoming every year more and more widely spread in their application. The theatres afford ample scope for the display of papier-maché ornaments; because the material is so tough that it will scarcely break, and so light that it requires much less fastening than the whiting and glue composition ornaments of former times. The counter-mould imparts to the ornament a hollowness at the back which economizes material and lessens the weight. The surface which the paper or papier presents is of a nondescript colour, arising from the mixture of various colours in the pulp, but it is fitted to receive any decorations in gold, oil-paint, size-colours, or varnish. Thus, an ornate frame for a looking-glass, made of papier maché, may be gilt with a degree of perfection nearly equal to that of a carved frame. But it is also capable of assuming a sculpturesque form. There were in the Great Exhibition, as many of our readers may remember, two statuettes after Michael Angelo, a copy of the noble horse's head from the Elgin marbles, and a bust of some celebrated man, all

formed of papier maché, and deriving therefrom a toughness which defies almost any power of breakage. The Corinthian capital in this material, set up on a pillar in the western nave, was an example of the more ordinary application for ornamental purposes.

There is another modern decorative material, still more recent than papier maché, but like it honoured with a French name: we mean *carton pierre*, which may be interpreted *stone cardboard* or *pasteboard*. This more nearly resembles plaster than papier maché; it has a little paper in it, a great deal more plaster, and one or two other substances; the mixture thus produced is fashioned in moulds, and is applied to various ornamental purposes, but it is much heavier than papier maché. The beautiful internal decorations at the Lyceum Theatre are, we believe, made of carton pierre. Carton pierre is manufactured in England chiefly by Messrs. Jackson, but it appears to have been a French invention, and to be made in France and Germany more largely than in England. The *carton pierre* of the one country, and the *stein pappe* of the other, seem to be pretty nearly the same material: viz., a kind of liquid plaster combined with other materials, *poured* instead of *pressed* into moulds, and backed with a stratum of paper to give strength. Some of our French neighbours displayed beautiful specimens of friezes, vases, pilasters, and bas-relievos, in carton pierre, at the Great Exhibition; while the Prussian exhibitor, Gropius, displayed some dozens of neat little statuettes in the same material. The noble chandelier for sixty lights, exhibited by Messrs. Jackson, was perhaps the best specimen of carton-pierre work.

But to return to papier maché. That the pulpy or *maché* paper is susceptible of being made into beautifully even flat surfaces, is exemplified in the thick *millboard* used by bookbinders. Time was when all such millboard was essentially pasteboard, produced by pasting together a large number of sheets of paper to the required thickness; but now the pulp is used. In the first place there is a flat table or slab, with a raised edge all round to form a sort of shallow mould. Into this mould the pulp is laded, to a depth depending on the thickness of the millboard to be made, and this pulp, by drying between felted cloths, by drying in the open air, by gentle pressure in a press, and then by powerful pressure between rollers, assumes at length that hard, tough, strong, smooth, uniform consistency which distinguishes millboard, and which makes that material so invaluable to the bookbinder. Mr. Bielefeld is about to introduce an important modification of this process in the production of panels for artists. He has produced panels eight feet by six, made entirely of papier maché half an inch thick, mounted on a skeleton wood support or frame; and the surface of these panels appears as if it would be admirably fitted for paintings, more durable than canvas, and less likely to split than wood panel; indeed, splitting is out of the question in respect to such a material. The bulkheads and the cabin partitions of some of the fine steamers of our day have been made of this material; it is tough and strong, and admits of any degree of ornamentation. The material is said to be a bad conductor both of sound and of heat, and has thus a twofold recommendation for room partitions. It seems to have been some such material as this which Mr. Haddan contributed to the Great Exhibition, in the form of panels for railway carriages, or rather for the whole broadside. It is alleged that such panels do not shrink, and do not require grooves for fixing; whether they will bear being 'run into' better than other railway panels, has probably not yet been tested.

Now we may turn our glance to that which, though not really papier

maché, is much more extensively known by that name than the material just described. The gorgeous contributions to the Hyde Park collection must be in the recollection of most persons. That paper, even with the adventitious aid of painting, and varnishing, and polishing, and gilding, and inlaying, should be wrought into such beautiful forms, might well excite the wonder of those to whom the manufacture was new. It was no small triumph of skill to produce, out of such a substance, the pearl inlaid pianoforte and music stool; the Victoria Regia cot, designed by Bell, the sculptor, and decked with emblematic devices in gold and colours; the pearl-and-gold inlaid loo-table; the Lotus work-table, designed by Bell; the pearl-inlaid and gilded work-table, in a form suggested by Benvenuto Cellini's vase; and Bell's chess-board for his "Parian" chess-men—to say nothing of the chairs, tables, sofas, cabinets, secretaries, screens, vases, writing-desks, blotting-folios, work-boxes, papetières, inkstands, envelope-cases, card-boxes, flower-stands, tea-trays, coffee-trays, wine-trays, standishes, crochet and netting-cases, and the numberless things which modern refinement has rendered familiar to us. The Furniture Courts in the Exhibition certainly glittered with these productions.

It would give a better idea of the manufacture (although somewhat lowering to its dignity) if these productions were called *pasteboard*, for pasteboard they certainly are, as the reader will presently see. It was towards the close of the last century that iron tea-trays began to be imitated or superseded by papier maché, and from these trays has gradually sprung up an important department of Birmingham industry, a department in which it is pretty generally admitted, we believe, that Birmingham excels all other places.

Although the real papier maché snaps up all kinds of paper indiscriminately, with most impartial fairness, the tea-tray paper (if we may so term it) is not so easily satisfied; it requires whole sound sheets to work upon, and these sheets must have a certain definite quality to fit them for their destined purpose.

Let us watch, in thought, the making of a papier-maché tea-tray. In the first place we see that the paper employed has a grayish colour, and looks like thick blotting-paper; and in the next we see that a mould or form is employed to give shape to the tray. Artists or designers are constantly at work producing new patterns; but we are here supposing that a tolerably simple tray is to be manufactured. A model of the tray is prepared, giving the exact form and shape; and from this model a mould is cast in iron, brass, or copper, the surface of the mould corresponding, of course, with the interior of the tray to be made. Women and girls, seated at tables, cut up the rough gray paper into pieces of the requisite size, and these pieces are handed to the pasters, who are also women—for it is worthy of remark that this very pretty art is one which is capable of being conducted in many of its branches by females. These pasters have beside them a plentiful supply of paste, made of flour and glue dissolved and boiled in water. The mould is greased to prevent the paper from adhering. The first sheet is pasted on both sides, and handed to another woman, who lays it on the mould, pressing and rubbing and adjusting it until it conforms to the shape. Another and another are similarly applied, and the mould, with its threefold garment, is put into a drying room, heated to a high temperature, where it is brought to a dried state. It is removed from the stove-room, filed to give it a tolerable smoothness of surface, and then clothed with three more layers of paper, in the same mode as before. Again is the stove-room employed, again the pasters ply their

labour; a third time the stove-room, again the pasters; and so on, until thirty or forty thicknesses of paper have been applied, more or less, of course, according to the substance intended to be produced. For some purposes as many as a hundred and twenty thicknesses are pasted together, involving forty stove dryings, and of course carrying the operations over a considerable number of days. A mass of pasteboard, six inches in thickness, which is occasionally produced for certain purposes, is perhaps one of the toughest and strongest materials we can imagine. If a cannon-ball, made of such pasteboard, were fired against a ship, would not the ball itself escape fracture?

The mould being covered with a sufficient layer, a knife is employed to dexterously loosen the paper at the edges; the greased state of the mould allows the paper to be removed from it. Then are all imperfections removed; the plane, the file, and the knife are applied to bring all 'ship-shape' and proper.

Next come the adornments. The pasteboard itself is not beautiful, so beauty is sought in other ways. Shell-lac varnish of very fine quality, coloured according to circumstances, is applied coat after coat, until a thickness is obtained sufficient for the purpose. The black polished surface of ordinary papier-maché trays is produced by black japan varnish, applied by women with a brush. But whether the varnish be black or coloured, it usually undergoes a rubbing and polishing to such a degree as to equal in brilliancy anything produced in the arts. It is said that the finest polishing instrument used to give the last finishing touch after all the 'rotten-stones' and 'emeries' have done their best, is the soft palm of a woman's hand; and that those females employed in this art, who are gifted by nature with the much-coveted charm of a soft and delicate hand, find it commercially advantageous to preserve this softness and delicacy by a degree of gloved carefulness not usual in their rank in life. What will the poets say, when woman's hand is thus spoken of?

Then ensue the painting and the gilding, the bedizenment with gaudy show, or the adornment with graceful device, according as the goods are low or high priced, or the manufacturer a man of taste or no taste. A kind of stencilling is employed in cheap work, but in better specimens the real artist's pencil is brought into requisition.

The inlaid-work exhibited in the higher class of papier-maché goods is very curious. A sort of imitative tortoiseshell is thus produced. A thin transparent varnish is laid on the prepared tray, leaf silver is laid on the varnish, the two are dried, and varnish is laid thickly over the silver, and pumice-stone is skilfully applied to grind away so much of the varnish at particular spots as will give to the whole the mottled appearance of tortoiseshell. Every day's experience tells us that imitations themselves are imitated. Not only is varnished silver made to imitate tortoiseshell, but varnished vermilion is made to imitate varnished-silver. A method of decorating papier maché with imitative gems has been recently introduced, in which some kind of foil or varnish is applied to the back of glass, and the glass employed as an inlaying. But perhaps the most striking ornamentation of this kind is pearl-inlaying, of which Messrs. Jennens and Bettridge's pianoforte was such a brilliant specimen. Here real mother-of-pearl is employed. A design is painted on the thin pieces of pearl with shellac varnish, a strong acid is applied, all the shell is eaten away except those parts protected by the varnish, and thus the pearl is brought into an ornamental form. The pearl is placed upon the wet japan of the papier maché, to which it adheres; and it is then coated with such a thick layer of varnish as to equal the thickness

of the film of mother-of pearl. It is varnished, dried, and rubbed with pumice over and over again, until a level surface is produced. It may be easily conceived how excellent the varnish and the mode of application must be to render such a thickness of applied varnish durable. The firm lately mentioned have made a complete suite of papier-maché drawing-room furniture for the Queen of Spain, decorated in this remarkable way.

But it is doubtful whether this excessive glitter of polish and pearl will have a permanent reputation. Something more sober will probably live longer. At any rate, when we find Mr. Owen Jones supplying Alhambraic designs, and other artists pictorial designs, for tea-trays, we find a nearer approach to fine art. The papier-maché contributions to the Great Exhibition from the Messrs. Spiers of Oxford were remarkable, inasmuch as the two or three hundred specimens contained views of about a hundred and fifty public buildings and interesting places in and near that city. There is in many of these specimens a mediæval taste in ornament fitted to the mediæval state of feeling in Oxford.

## Paper-Hangings.

Many are the curious applications of paper not yet touched upon; but, as it would be vain to attempt an enumeration of them all, we will be content with a little notice of a paper product familiar to the denizens of most English houses of a decent class.

Paper-stainers and paper-hangers are not very happy in the terms they employ; for the paper is not stained, neither is it hung. But criticism would ferret out much to cavil at in such matters; and we will therefore take matters as we find them. It is obvious that the use of paper as a substitute for the tapestry of old times originated the title of *hangings*, as applied to wall-papers. There is evidence that it was somewhat about two centuries ago when this substitution began to take root. Whatever may be said concerning the higher ranks of society, it was certainly a favourable invention in respect to the cleanliness, the neatness, and the comfort of the houses inhabited by lower grades. This was true even when a pernicious Excise duty pressed upon this manufactured product: it is still more true now that the produce is freed from such shackles.

The humblest and cheapest wall-papers are painted by the stencil method; or at least they used so to be before the recent great advancements in the art. The stencilling is simply this:—a pattern is cut out, in a sheet of paper, of leather, of tin, of copper, or of some other convenient substance; a vessel of liquid colour is provided; a long strip of paper is laid on a bench, the stencil plate is laid on the paper, a brush dipped in the colour is worked over the plate, and the colour thus finds its way to the paper in all those parts where a pattern is cut in the plate. If there be three or more colours, there must be three or more plates, each cut in exact conformity to the device for one particular colour.

But the pattern is never very elegant, never very nicely delineated by this method; and it has been to a great extent superseded by the *block* method, in which the wood-cut system of printing is imitated. A block is carved in hard wood, the surface of which is to represent the device for one colour, another is carved for a second colour, another for a third, and so on—the number of blocks equalling the number of colours, and all very carefully adjusted to work in harmony as to the general pattern. The artistic part being thus prepared, matters proceed somewhat thus:—a long strip of paper

is laid down; a ground of 'distemper' or size-colour is applied with a brush, and dried; colours are prepared, as many as there are blocks; one colour is daubed over a soft leather cushion; a block is inverted on it, and made to take up a layer; this layer is applied to the paper; and other impressions are printed side by side until the whole length of paper is finished. Then another block and another colour are used; then a third; and so on; and the skill of the workmen is shown by rendering these several junctions as little visible as possible.

The modern method of *cylinder* printing is, however, the great step in advance. The making of continuous strips of paper, instead of having to paste sheets together, was one notable aid to the paper-stainer; the removal of the Excise duty has been a second; while the use of the cylinder machine has capped those improvements, and rendered it possible to make wall-papers at a farthing per yard. When we consider that paper-hangings used to pay—besides the duty per lb. on all paper—no less than 1¾*d.* per yard in their capacity as wall-paper, we may cease to wonder at the lowering of price which recent times have witnessed. And it is not difficult, too, to see how the cylinder method should bring about a lower rate of charge than the block method. Calico printing, we know, has borne witness to an analogous fact; the cylinder machine has given tasteful print dresses to the wives and daughters of men who could not have borne the price of such productions in past times. The analogy is very close throughout. In the one case cotton, and in the other paper, is made in one continuous length; in both cases this length is wound round a beam or roller; in both cases there are engraved cylinders, as many as there are to be colours, and each having a device of its own; in both cases there are as many troughs of colour as there are cylinders; in both cases the cylinders feed themselves with colour, but in such a way as to take up the colour on the *raised* parts in the one case, but on the *sunk* parts in the other; in both cases the endless web is drawn in between rollers, and made to pass over all the colour-wetted cylinders in succession; in both cases the complete pattern is seen to be printed by the time the material leaves the machine; and in both cases the printed strip undergoes a rapid drying process. The Great Exhibition, among its numerous specimens illustrative of paper-hangings, contained some which showed in a marked way the facility now attained by the cylinder method. Among Messrs. Haywood's contributions were wall-paper in *fourteen* colours, all produced at once by fourteen cylinders in one machine!

Many are the means adopted to give a decorative character to paper-hangings, besides the mere use of colours. Some specimens have a glossy ground, to which the attractive name of *satin* is applied; this effect is produced by the careful application of polishing powder to a surface painted the proper tint. Some have an appearance imitative of figured or watered silk, produced by passing the paper between slightly-heated rollers, which have the requisite design engraved upon them. Some have a cloth-like appearance, produced in a singular way: the device is printed on the paper with gold size, and over this is sprinkled coloured *flock*, which consists of woollen cloth cut or ground to a powder. Some of the *striped* papers are produced in a very remarkable way: the paper travels over a revolving cylinder, and in its passage touches against the open bottom of a trough, whence a continuous stream of liquid colour falls upon it; *blended* or *shaded* patterns are produced by a modification of this process; *bronzed*, *gilt*, or *silvered* papers are produced by printing a device with gold size, and applying the metallic adornment in the state either of powder

or of leaf. Some papers, to which the enticing designation of 'washable' is given, are printed with the colours prepared in oil or varnish, which will bear a water-washing process with impunity.

In these days, when artistic design occupies an uppermost place in the thoughts of those who would advance our manufactures, paper-hangings have not escaped scrutiny. No definite principle of ornamentation has yet been introduced in this art. Sometimes we see cottages built one over another from the floor to the ceiling, all exactly alike, and each enclosed in a border. Sometimes animals, sometimes trees or flowers, are repeated in a similar way; and the result is, that whatever may be the merit of any one compartment, or however gay the general effect produced, there is nothing sensible or artistic in the whole vertical surface viewed at a glance. On the other hand, any attempt at *perspective* views is vitiated by this objection—that all perspective supposes a point of sight to be chosen, at a particular distance from the picture; at any other distance distortion instead of symmetry is produced. At one time there was a fashion to give a *sculpturesque* tone to paper-hangings, by representing statues and bassi-relievi on neutral ground; at another time copies from historical pictures had a reign of favour; while the *architectural* principle predominated at another, by the representation of Grecian temples, Gothic chapels, Italian palaces, Chinese pagodas, and such like.

The late Mr. Loudon, who was as untiring in his writings concerning house decoration as on gardening matters, threw out a suggestion for a new kind of paper-hanging for school-rooms and nurseries, "formed by printing figures of all the commoner and more important animals and plants, with the scientific and popular name beneath them; each plant or animal being surrounded by lines, so as to appear either in frames or as if painted on the ends of stones or bricks. The advantage of the framed lines would be to give unity to the paper as a whole, and also to admit of repairs by taking out any single frame or stone, and replacing it by another." "There is no reason," he adds, "but the expense, why a geographical paper should not be formed; or one exhibiting all the principal rivers, mountains, or cities in the world; or the portraits of eminent men, with their names; or perpetual almanacs; or lists of weights and measures; or chronological or arithmetical tables; or, in short, any useful and instructive subject, which it would be beneficial to the cottager to have frequently before his eyes."

Something like this has been suggested, adapted to a higher order of artistic work. It is this—to have a pattern printed on wall-paper, with a delicate and graceful style of ornamentation; either trellis-work, or tendrils of plants, or arabesque patterns, but leaving spaces, or oval or circular medallions, in which subjects could be afterwards painted by hand. The lady-artist of a mansion might thus display her industry and taste on the papered walls instead of on the crochet curtains or the rug-work ottomans; and she might thus recall the feudal days when high-born dames wrought the tapestry or wall-hangings for their own boudoirs.

Unless paper ceases to be a material for wall decoration (and there seems no reason why it should so cease), the time has come for a little more artistic meaning in the designs—something like an approach to a *principle* in decorative patterns. The people, the paper users, will welcome a new infusion of mind in this art; for many of the "curiosities of industry," in the shape of paper-hangings, are felt to be very absurd curiosities indeed.

# PRINTING: ITS MODERN VARIETIES.

THE curiosities of Printing are becoming so numerous, that they present themselves to our notice in all that pertains to the art, whether primary or collateral. In the types themselves, in the mode of producing them, in the mode of arranging them for printing, in the printing operations, in the inking contrivances, in the presses and machines, in the application of colour by printing, in the stereotyping arrangements, in the links which connect the typographer with the lithographer, and the engraver with the galvanist—in all these matters, the curious and valuable novelties of recent years are very abundant.

In this, as in other sheets of the series, we describe the old and familiar processes only so far as will render the novelties more intelligible.

## TYPES AND TYPE-FOUNDING: OLD AND NEW.

The founding or casting of that all-important little implement, a printing type, is one of the prettiest in the whole range of the typographic art—so much does it depend upon a nice discrimination in the hand and eye of the workman, and on so miniature a scale is the apparatus.

But before describing modern types and type-making, it may be well to remind the reader that the first or original printers did not employ such types: they arrived at this stage of completeness by degrees. Very early in the fifteenth century, a method was practised of cutting lines *in relief* on blocks of wood, and printing from those lines when inked; this was the forerunner of the *wood-engraving* of modern days. There is indistinct evidence of such an art being practised earlier; but it is, at all events, known that small cheap pictures, produced in this way, were sold in Germany and Italy at the period named above. Strangely enough, *religious books* and *playing cards* were the first works which received this kind of printing; but other works speedily followed. The same block of wood which contained a picture came, by degrees, to have words and sentences also cut on the surface; and these were printed at the same time as the picture. The next step was, to cut up the text portion into separate letters, so that they might be recombined for any other work; this was the *great* invention in printing, and the one to which the rival claims of Gutenberg, Faust, Coster, and Schoeffer relate. A further stage was, that of engraving a model of each letter, striking a mould from the model, and casting separate letters from the mould; this, which is essentially the principle of modern times, seems to have been first adopted about 1450. These matters being premised, we may now glance at the types and the type-makers.

Types for printing are usually about an inch long, with a letter *in relievo* at one end, and a nick or notch near the other. They are cast in a mould, and are formed of lead to which about twenty per cent. of antimony has been added. But before this casting takes place, a very important affair has to be attended to: a *mould* has to be made; and to make this mould a *punch* or *die* is requisite. This punch is the production on which the type-founder most

prides himself; since the beauty of the type depends so much on the excellence of the punch. This punch is a small block of steel, on one end of which a letter is formed by a very careful application of punching and engraving or cutting; the steel is softened to aid these processes, and is hardened afterwards. The letter or character is one of the many which the type-founder must produce. There must be twenty-six punches of each *fount* or size of type, for the small letters; there must be an equal number for the large and for the small capitals; there must be ten for the numerals; there must be commas, colons, and all the other subsidiary characters, ornamental as well as significant; there must be an *Italic* series as well as a *Roman* series; there must be different sizes, agreeing in all else but in size; there must be foreign alphabets, such as Greek, Hebrew, &c. It thus arises that the types amount to a very large number; and there must be a separate steel punch for each. The sizes of type, irrespective of other differences, are known by names which are a perfect mystery to readers generally. To explain why these sizes are called *double pica, paragon, great primer, English, pica, small pica, long primer, bourgeois, brevier, minion, nonpareil, pearl, diamond,* and *brilliant,* would be no easy matter. They are compared one with another, by printers, in reference to the number of lines of each which fill a column of twelve inches, if packed closely side by side; thus a foot of double pica would contain about 42 such lines, whereas a foot of diamond would contain 205 lines. The present sheet is printed with long primer type, which has 92 lines to the foot. In respect to the punches, fashion exerts its influence, as in other matters; thus, in the French types, and the punches which produce them, there is seen a tendency to finer thin lines (or 'up strokes') than in the English; and we may also see among those who have 'mediæval' tastes (to employ a much-used phrase), a wish to revive what others would call old-fashioned type.

The punch for a letter, then, is formed; and an impression from it is made upon a piece of copper, which obtains the name of the *matrix.* This matrix, when the casting is about to take place, is placed within a small but curiously-constructed *mould,* wood without and steel within. There is a furnace containing molten type-metal; a workman holds the mould in his left hand and a tiny ladle or spoon in his right; he lades from the molten mass a ladle-full, pours it into the mould, gives the mould a sudden upward jerk to force the metal into all the little cavities, opens the mould into two parts by means of a spring, picks out the hot but solidified cast type with a hook, and closes the mould again for another casting. And when the reader is told that the whole of these successive movements occupy collectively only *an eighth part of a minute,* he will be prepared to consider the art of type-casting as one of the most striking exemplifications of manipulative skill derived from long practice.

Thus types are cast, thousand after thousand from each matrix; and when another letter is wanted, another matrix is placed in the mould. A few finishing touches bring the types to the state required by the printer. Boys break off the bits of superfluous metal which adhere to the types; this they do at the rate of three or four thousand in an hour. Other boys rub the sides of the type against a grit-stone, to remove asperities; and this they do nearly as quickly as the breaking off. Men then finish the types, by planing them till they become all exactly equal in length, and examining each with a magnifier, to see that every single type is fitted for its purpose—all ill-formed types being rejected, as unworthy companions for the rest.

It was very interesting to see, at the Great Exhibition, specimens of the types made by the old firm of Caslon, through so long a period as a hundred

and thirty years; they showed how fashion has varied between 1720 and 1851; but in regard to actual excellence, some of the old type would bear safe comparison with our modern productions, though not when taken collectively. A proof was given of the extreme accuracy in the form of modern type, by a mass of two hundred thousand very small types, suspended in the air with no other security than the lateral pressure of screws in the chase or frame; the type was of the kind called '*pearl*,' and the whole mass, thus supported *only* at the sides, weighed a hundred and forty pounds. A new type has been cast by Messrs. Miller and Richard, called '*brilliant*,' said to be the smallest ever produced, being smaller than the '*diamond*' type used for the notes of the smallest bibles. Gray's Elegy was displayed at the Exhibition, printed with this type within a space of four inches by three, the whole thirty-two verses of four lines each; this was perhaps the closest specimen of printing ever yet seen. Another curiosity consisted of the types invented for the phonotypic and phonographic systems, at present struggling to maintain a recognised existence in society. A singular plan for printing in types from two colours (whether or not yet acted on we do not know) was exhibited, in which the letter-types are of unequal height, so that the inking roller, in applying one of the two colours, shall touch only the projecting types. Books and newspapers have often lines printed either horizontally or vertically, to separate columns or to tabulate numbers; there are also numerous small ornamented types used in various parts of some books; and one of the type-founding establishments hit upon the expedient of combining some twelve or thirteen thousand of these decorative and line types, to form a picture of the front of the Free Church College at Edinburgh: it was a toy certainly, but it was intended to exhibit the powers of the establishment in this department of type-founding.

There are many peculiarities in the types used for printing music. The ordinary music pages, in the extravagantly-charged sheets of the music-publishers, are engraved on zinc-plates, and it is therefore easy to combine all the requisite characters and symbols; but the arrangement of separate metal types for this purpose requires the exercise of much ingenuity; for not only must the proper musical symbols be given, but the five lines of the staff or stave must be preserved; and the type-founder has to calculate how many combinations of form in the types will meet all the requirements of modern music. In the Exhibition there was one collection of music-type which comprised 315 separate types—315 separate letters (so to speak) in the musical alphabet. Let the reader examine closely any page of type-printed music: he will find that each musical line is built up with numerous fragmentary pieces. These pieces are separate types. Sometimes a type consists of an eighth of an inch of staff, with a crochet or a quaver attached; sometimes it is a minim rest, with two bits of staff above and below it; sometimes it is the thick double line for a semiquaver, ready to be fitted on to any note either above or below it; sometimes two notes, with an interval of a musical third between them, are formed on the same type, with fragments of horizontal lines either *through* them or *between* them, so as to adapt them to take a position either on the lines or on the spaces of the staff. It is an evidence of the skill with which this kind of printing is now done, that this piece-meal formation of a music page can only be seen by tolerably close inspection. Nothing but experience can decide as to the best forms and combinations to give to the types. In practice there are two different plans acted on—the complete note being cast in one piece, and the note being in five pieces, for the five lines of the staff. Both plans are adopted as may be most convenient; but music-type founders are

endeavouring to devise some medium system which shall combine the excellencies of both.

Many and varied have been the attempts of type-founders to devise some mode of combining letters into one type, as a means of saving time. In nearly all systems of stenography, or short-hand, small and much-used words are represented by a single symbol: such as *and*, *the*, *of*, &c.; as likewise the most usual prefixes to compound words, such as *in*, *con*, *re*, &c.; and the most used terminal syllables, such as *ion*, *ment*, *ing*, &c. In the Exhibition there were some American types cast on this principle, viz., that of having one type for a constantly-recurring word, instead of building it up with as many types as there are letters. The master printer on the one hand, and the compositor on the other, have to test the value of all such innovations on the ordinary practice; the former has to bear the expense of making new punches and matrices for the compound types; while the compositor has to find little cells for the extra types, and to lay his fingers upon them as readily as upon the ordinary type. It is due, however, to the American exhibitor, Mr. Tobit, to note, that much of the extra expense is avoided in his method, by forming the matrices on the electrotype principle, from the single types themselves, without the engraving of any new punches.

One of the most remarkable typographical displays in the Exhibition was the collection of Chinese types, or at least types to represent Chinese characters, in the Zollverein department. They were manufactured by Beyerhaus of Berlin, for the American Missionary Society. The Chinese vocabulary is made up of a number of distinct words, which are not built up from component letters, as in European languages, but have a good deal of the hieroglyphic effect about them. To imitate these words or characters by moveable types has always been deemed a difficult matter. M. Beyerhaus has analyzed the lines and dots of the Chinese language, so as to make 4200 letters out of them, or elements which will serve the compositor in lieu of letters. The steel punches of all these 4200 types were shown; and by various combinations of them, about 24,000 Chinese words or characters can be imitated; and it was very interesting to see copies of the Bible and the New Testament printed in Chinese by the aid of these types.

Another example, which illustrates the untiring industry of our German neighbours in the type-founding art, was to be met with in the Saxon section. It consisted of a volume relating to ancient Egypt, printed in nearly thirty languages, and also in the Egyptian hieroglyphic characters. These required no fewer than 3000 punches, matrices, and type-castings, to produce the type for these hieroglyphic characters.

M. Le Grand, of Paris, has devised an ingenious mode of casting many types at once, by ranging the matrices side by side in a mould which will contain them all. He casts from 100 to 150 at once, and claims to have the power of producing 30,000 to 50,000 per hour by the aid of two men only.

While this paper is being prepared for press, an advertisement has appeared announcing a new Type-making Company, which is to be established for working a recent patent. The types are to be made of hard wire, cut and stamped without any process of casting; and it is alleged (in the bright language of advertising) that types can be thus made at the rate of a hundred in a minute.

The facing of types with copper by the electrotype process, as a means of rendering them durable, is a modern project noticed in a former number of this series.

## The Compositor and his Apparatus.

It is scarcely necessary to inform an intelligent reader in the present day, that a *compositor* is one who puts the types together, for printing.

The labours of the compositor certainly require as much exercise of mind, eye, and fingers, as any of the ordinary handicraft employments. He is expected to decipher the writing, good or bad, of the author whose manuscript he is putting into type. He has to manage the punctuation, which authors too generally care very little about; and he often rectifies an occasional error arising from haste in writing or from transcription. His eye guides his fingers (or his fingers almost guide themselves) to the cells where the proper letter-types are to be found; and the formation of letters into words, words into lines, lines into columns, columns into pages, and pages into forms or sheet-surfaces, taxes all his powers—mental, visual, and digital. He has to "mind his *p's* and *q's*," not only in the literal sense of that phrase, as the *p* appears on the type like a *q* to the unpractised eye, but in many a figurative sense also.

The compositor has his types placed in small *cells*, which are combined into a *case*, and two pairs of cases occupy a *frame*. He has one pair of cases for Roman, another for Italic, or a smaller type for notes. The upper case of each pair contains large and small capitals, numerals, accented vowels, and a few other types; the lower case contains the small letters and the space-types. Some of the cells are larger than others, to contain the letters most in use. In the English language the letter *e* occurs more frequently than any other; then *t;* then *a;* then *i*, *n*, *o*, and *s; z* is the least in use, there being sixty times as many *e's* as *z's*. In a 'fount,' or complete set of types, consisting of 106,000, there are 12,000 *e's*, rather more than one-ninth of the whole. The letters are not arranged alphabetically in the case, but those which are most in use are placed nearest to the hand of the compositor: a conventional arrangement, wholly dependent on practical utility. So well does the compositor know this arrangement, that his fingers dip almost intuitively into the proper cell for any required type; no labelling or inscribing being at all necessary.

Step by step does the compositor build up his letters into words, and his words into sentences. Let his first word be "Industry:" he takes an I from the upper case, or case of capitals, and then his fingers dip successively into the cells of the lower case which contain n, d, u, s, &c. Each type, as he picks it up, he places against a ledge in a little implement called the *composing-stick*. When he has arranged side by side the eight types for the word "Industry," he takes a 'space' out of another cell, and uses it as a boundary between this and the next word—the 'space' being a blank type, too shallow to come under the action of the inking apparatus. Then he proceeds to the second word, and so on till he has words enough to fill one line of a page or column. He then begins a new line, and by the time he has thus collected about a dozen lines, his composing-stick is full; the contents are carefully lifted out in a mass, and placed in what is called a *galley*. He then gets another stick full, and transfers it in a similar way, until at length the galley becomes full. Thus he proceeds; at the rate of about fifteen thousand letters in a good day's work.

The precautions which the compositor has to take are many and varied. After having mastered the difficulties of the manuscript (which he reads two

or three lines at a time, and which he places in a convenient spot before him), he selects the proper types to make the words. It is found that rather over five letters is the average length of all English words; but, as a line must not end in the middle of a syllable, much tact is necessary in *spacing* the words, so that none may appear too crowded, none too wide. Then, again, he must take care that none of his letters are placed upside down; a little nick or notch in the shaft of each type greatly facilitates the eye and finger in avoiding mistakes in this matter. Again, when his stick is filled, in lifting the type to the galley, he may have a slight mishap; when lo! down go the types, the fruit of his labour, in confusion on the floor, to form what printers, with mortifying irony, call *pie*—a grievous pie, which often falls to the share of the apprentice-compositor. The workman who makes "pie" has to taste its bitterness doubly, for he must re-distribute the type before he can re-compose his page, and he is paid neither for the one nor the other.

The processes of adjustment and rectification, after the composing but before the printing, are numerous. The column of types is bound tightly, and a 'proof' or impression printed from it; or sometimes a whole sheet-full of pages is printed at once for a proof. A strange medley is this proof sheet. Let the compositor be as careful as he may, the mistakes are very numerous—sometimes his own fault, sometimes the author's. A wrong letter appears in one place; a wrong word in another; a letter or a word or a whole sentence may be omitted; a word may be given in duplicate; two words may have been made to coalesce without a space; a letter may be reversed; two or more words may be transposed; a word which should begin one line may be seen at the beginning of the next following line; sentences may be in different paragraphs which ought to form parts of the same paragraph, or *vice versâ;* a comma may be given instead of a semicolon, or the stops generally may be either redundant or deficient; a word may be printed in Roman which ought to be in Italic, or the reverse; a word may be in capital instead of small type, or the reverse; a letter belonging to a wrong fount or size may have become mixed up with the proper type in the cell; a space may protrude so much as to be inked; part of the letters of a word may slip down below the general level of the line—all these mistakes may occur, and do occur. Some of the errors, if left uncorrected, would be serious; some are simply ludicrous. An intelligent man, midway between a thinker and a worker, reads the proof attentively, detects the grammatical and typographical errors, and marks with a pen the kind of corrections necessary. The proof goes back to the compositor, who has to take his work to pieces in most heart-ache style—at least so it appears to a looker-on, who can hardly feel other than regret at so much patient labour being rendered useless; for if the errors are numerous, their reparation may take as long as re-composing the whole sheet. The wages of a compositor are so calculated as to include payment for the production of a *correct* proof, as well as the distribution of the type after printing; consequently the correction of all the errors which may fairly be imputed to himself, in the proof, is a part of his engagement, for which he receives no extra pay; and he has thus every inducement to strive after the attainment of a good, clean, perfect proof in the first instance. But there are other errors for which the compositor is not responsible. A second proof, or *revise*, is examined by the reader, to see that his corrections have been attended to; and is then sent to the author, who makes such changes as he may deem necessary; and the compositor is paid by the hour for the extra labour resulting from this revision. According

the extent of the corrections, and the number of times they are made, these revisions have to be repeated.

The corrected pages are grouped in their proper order, so as to print a sheet of quarto, octavo, duodecimo, or any other size. The order in which they are arranged depends on the number of foldings which the sheet is to undergo. In the present sheet, for instance, the reader will find that although there are twelve pages on each side, these twelve follow each other in (apparently) very irregular order, when the sheet is open; yet all find their proper place when folded. In arranging the pages for the press, they are placed at proper distances, and are separated by pieces of wood called *furniture*, wide enough to form the margins to the several leaves; and the whole are then wedged into an iron frame called a *chase*. Each side of the sheet must have an arrangement of this kind; so that there are ultimately prepared two *forms*, as they are called, each properly fitted for printing one side of a sheet.

When the printing is finished, or the stereotype cast (as the case may be), the compositor has to undo his work. The type having been cleaned from the ink, the *form* is pulled to pieces, the *furniture* is removed, and the types are separated —each to be returned to its proper cell. This is a pretty and remarkable process. He takes a quantity—perhaps a dozen lines—in his left hand, takes up one or two words from this quantity between the fingers and thumb of his right hand, and drops them into the cells with almost inconceivable quickness. An experienced compositor will thus distribute *fifty thousand* types in a day, involving very few mistakes.

A small mechanical adjunct to the labours of the compositor has been introduced in Belgium. Instead of tying round a page of type with string, to enable him to lift it in one mass, there is here substituted an iron frame—light, strong, and easily adjusted to its place. So tightly, indeed, does the frame hold the type, that in cases of emergency printed impressions are said to be obtainable from the type in this state, without any other fastening.

Another trifle—the value of which must be determined by the compositor, and by him alone—is Mr. Gallard's portable composing-frame, which was shown at the Exhibition. It is intended to provide temporary accommodation for cases at the imposing-stone during correction of proofs; and also for extra cases near the compositor's frame, at times when he is engaged upon work which has a mixture of Italic or other type with the ordinary type.

Can the aid of machinery be brought into requisition in compositor-work? This question has been many times asked; and many ingenious persons have endeavoured to give an affirmative answer to it. About ten years ago the attention of the printing fraternity was much attracted towards two rival machines, one by Messrs. Young and Delcambre, and one by Captain Rosenberg. Both machines could compose type by automatic agency, and both were highly ingenious; or, more correctly, both substituted mechanism for human fingers in certain parts of the apparatus.

In these two machines there is a key-board on which the compositor plays; he has not to deal with *flats* and *sharps* and *naturals*, but with the letters of the words transmitted to him by the author. To use our former illustration (the word 'Industry'), the compositor, instead of dipping his fingers into eight little cells, presses his fingers on eight different keys of his silent pianoforte. What, then, is the result? In Young and Delcambre's machine, the key moves a lever; the lever pushes a type out of a little receptacle; the types slide down an inclined plane into a funnel or spout, and thence into a box, where the compositor takes them up and arranges them in his composing-stick. In

Rosenberg's machine, the key detaches a type from a vertical rack; the types, when detached, range themselves on an endless belt; they leave the belt and range close together in a receiver; and when one line-full is thus formed the machine rings a bell, and the compositor takes away the line of type, and leaves room for another. In the one, the types require to be distributed in the same piece-meal way as in ordinary composing; while Rosenberg's machine was accompanied by another for effecting the distribution also. Rosenberg's machines were therefore more complete than that which was invented shortly before them; and very high anticipations were formed of their value. But these anticipations have not been realised. Men are still required to attend on the machine, and to do part of the work; it is found that the machine cannot *think* sufficiently, and that nothing is saved by the time all the corrections and adjustments are made.

M. Sörensen's very remarkable type-machine had not, we believe, been known in this country until the recent Exhibition. The singular bird-cage-looking apparatus, which formed one of the small number of contributions from Denmark, has the merit—be this little or much—of being in many points quite unlike any that preceded it. It is no easy matter to describe this machine. The reader may picture to himself two circular cages, one placed over another, and the upper one capable of revolving on its axis independent of the lower. The upper cage is for *distributing* type; the lower for *composing*. Suppose a sheet to be printed off, and the compositor required to distribute the type; he takes them up a few at a time, and places them between the brass bars of the upper cage, where they slide down to a plate which separates the two cages. This plate has perforations, each one so formed as to admit one kind of type-letter only; and as every type-letter has side notches differing from those of every other letter, each type can only pass through one particular perforation; and it is by slowly revolving the upper cage that the types one by one find the proper perforations through which they may creep. The lower cage has as many vertical brass bars as there are letters of type; and by degrees the space between any two bars becomes filled with type all of one letter—this constitutes the *distribution*. Then for the *composing*. The compositor plays upon a set of keys; these keys act upon strings; the strings act upon springs; the springs push out or let out the requisite types from between the bars of the cage; the types descend to a sloping plate, then through a spiral tube, and then into a receiver, where they range themselves in soldierly order side by side. If the compositor has played the keys rightly, the order of arrangement in the types is also right. A foot-pedal moves the receiver along gently, ready to accept the types as they drop successively into it; and when a line is formed, it is removed, and the receiver adjusted for another.

Now for the alleged advantages and disadvantages of this remarkable machine. Is it not a troublesome affair to place all the types between the bars of the distributing machine? M. Sörensen asserts that it occupies only one-tenth the time of ordinary distributing. Does not the machine require most delicate workmanship, that all the rods, incisions, types, notches, and projections, may fit well into each other? M. Sörensen admits that this is a *sine quâ non;* but considers that this ought not to be an objection in an age of high mechanical ability. Will not the types be dearer to cast, and weaker under the press, than ordinary type without these peculiar notches? M. Sörensen thinks that the slight increase in expense will in part be counterbalanced by less weight of metal; and that the types, though yielding to violence, would bear fair pressure. Would not the expense of such a machine (100*l.*) neutralise its

advantages? No, says M. Sörensen; divide the expense over a long period, and you will have a good margin left. Is not the method difficult to learn? M. Sörensen states that any person could learn to use this machine more quickly than the ordinary composing system, and that a compositor could master it in a few days. Will not the saving of time be neutralised by the necessity for hand-labour in dividing, spacing, adjusting, *italic*-ising, and so forth? Lessened, says M. Sörensen, but not neutralised. Would not the compositors oppose it? If they did, says M. Sörensen, the opposition would yield after a time, as in all similar cases.—These are the statements for and against; and it may be hoped that so ingenious a machine may have an ample testing, which it does not seem yet to have had; indeed we are not aware that M. Sörensen has ever yet actually set the machine to work in a printing-office; and all mere *model* experiments will fail to place the inquiry on a proper commercial basis.

## Stereotyping: its Purport and its Varieties.

That cheap literature owes much to stereotyping, is beyond question; as the process is one of those which economise the outlay in printing. For works of small circulation it is useless, or worse than useless; but when there is a very large demand for a book, or the demand spreads over a considerable space of time, then does stereotyping lessen the expenses of the publisher. It does so for the following reasons. If the publisher over-estimates the demand for a new book, he prints too many copies, some of which remain a dead loss to him on his shelves; if he under-estimates the demand he prints too few, and has all the expense of composing the type to incur over again. But if he bestows the time and labour of making stereotype casts from his type, he can then print from these plates just as many copies as are wanted, and do this from time to time during an indefinite period. He need not keep the type standing; he can distribute and use the type for other works, knowing that he has a source of power in his stereotype plates. And, moreover, he can make two or a dozen or any number of stereotype casts from each page; so that he could print two, or a dozen, or any number of copies at once, with the requisite press or machine arrangements, and all with one original 'setting up,' or composing. There is this consideration, too; that a woodcut becomes somewhat worn when a large number of impressions have been taken from it; but by a series of stereotype casts from it, the power of printing from it becomes practically illimitable. The reader will then bear in mind that, so far as any one copy is concerned, stereotype-printing is not better than type-printing; on the contrary, the highest class of work is generally type-printed; but when a large quantity of one kind is required, the advantages of the stereotype method, both in time and money, are quite irresistible.

It is certainly extraordinary that, after two castings, a stereotype plate, even from a woodcut, should be fine and sharp enough for printing; it shows how great is the skill now attained in the art. That there are *two* castings, many readers are apt at times to forget; but a moment's consideration will show that such must necessarily be the case; for the first cast will give hollows instead of protuberances, and *vice versâ;* and hence another is required to restore the original aspect of the surface—just as in all other processes of casting, founding, or moulding; where a *model* is employed to yield a *mould*, and the mould is employed to yield *casts*. In stereotyping, the page of type, or mingled type and woodcuts, is the *model;* a plaster impression from this is the *mould;*

and the stereotype plate is the *cast*. The method was first practised at Edinburgh a century and a quarter ago; but it was not brought much into requisition until towards the close of the last century; and did not become a really important commercial element in printing until 1832, when the vast sale of the Penny Magazine produced a revolution in cheap literature.

Stereotype casting is managed simply as follows. The page of type, as clean and perfect as possible, is wedged up closely in a moulding-frame; the surface of the type is slightly oiled; liquid plaster is poured upon it until the moulding-frame is filled; the solidified mould is removed when cold; and after being trimmed, it is placed in an oven to bake or dry. Then begins the metallic casting. The metal is melted in a cauldron; the plaster-mould is placed in a peculiar casting-box; and, by a very nice adjustment, the mould and the box are both immersed in the molten metal, in such a way as to allow a layer of metal to form on the surface. When removed from the cauldron, and taken from the casting box, and the plaster mould broken from it (for a mould is destroyed for each cast made), the plate is carefully examined; the back is rendered perfectly level by being turned in a lathe; and the face is freed from any slight defects which may disfigure it. There is thus produced a stereotype plate capable of bearing the action of the printing press or machine.

This is the ordinary stereotype process, but many recent novelties have been introduced in aid of it. The application of gutta percha to printing was noticed in a former number of this series; but we may here describe one or two of these applications more fully. Mr. Muir, of Glasgow, has invented a mode of stereotyping, managed in the following way. A page of common type is first set up, and well fixed; a warm cake of gutta percha is applied to it, screwed down tightly, and allowed so to remain a quarter of an hour; when this gutta percha mould is removed, it is brushed over with fine blacklead, and an electro-copper cast taken from it; the printing is then effected from this cast. It is found that gutta percha constitutes a very convenient and efficient substance for the mould, owing to the readiness with which it can be softened, and its toughness when cold; while the electro-copper cast is said to bear the action of the printing press throughout a much greater number of copies than an ordinary stereotype plate.

The same inventor also practises a plan in which the gutta percha performs not only its own work but that of the electro-copper also. A mould is taken from an engraved wood-block, in gutta-percha; and this mould, when brushed over with blacklead, is made to yield a cast also in gutta percha, in an exactly similar way; and from this cast the impressions are printed. It seems difficult to conceive that, after this double process, all the delicate lines of a wood-engraving should be preserved on the surface of such a material as gutta percha; and yet, without this preservation, the method would be practically valueless.

Bitumen is another substance which is competing with gutta percha for an honourable place among stereotyping materials. Messrs. Manchin and Morel have introduced a method which, though not yet much adopted in this country, is said to have found considerable favour in France. The cast, either from a woodcut or from type, through the intermedium of a mould, is formed of a bituminous substance, which is harder than type metal, and gives the markings with great clearness. It is said to be somewhat more expensive than common stereotype; we learn, however, that it is now being tested, and if found practically advantageous, will be brought at once into use.

It is really almost difficult to follow the novelties in this department of the printing art. There is a method of making stereotypes from paper, or rather papier-maché. From the description given in another part of this series, it will easily be understood that the pulpy nature of papier-maché would enable it to be used as a stereotyping material; but this application seems to be abandoned for others, especially that of stereotyping by electro-deposition.

So far as scientific completeness goes, no other stereotyping can bear comparison with the beautiful process last named: it is a very triumph of science applied to the arts; and as we find that our artistic manufacturers and fancy printers are every day availing themselves more and more of the process, we may safely conclude that it superadds practical usefulness to scientific precision.

## The Printing Press: Four Centuries' Progress.

We have not yet touched upon printing itself, the actual process to which all else is subsidiary.

As almost any kind of pressure is sufficient to transfer an inked impression to paper, a printing press *might* be one of the simplest of all contrivances; and that it is not so, is because modern society requires the printing to be effected both well and quickly.

It is interesting to trace the steps of progress, from the rude press of early times down to the mighty *Times'* printing machine of the present day. The first employed was nothing more than a simple screw-press, like a cheese or napkin press. The form of type being inked, was placed with a sheet of paper beneath the press, and the screw worked to give sufficient pressure. But this was a sadly lingering process, since there must be as many screwings and unscrewings as there are copies to be printed. The first improvement was made by Blaew, a Dutchman, who gave an elasticity to some parts of the press, which sharpened the impression and lessened the wear of the type. Still the screw principle remained, and was adopted everywhere until the commencement of the present century.

It is not often that a nobleman is chiefly distinguished for his mechanical inventions; but the late Earl Stanhope will be known for his printing press long after his senatorial labours are forgotten. This was the first really great improvement in such machines, and has been the parent of all subsequent advancements. It was made of iron instead of wood, and thus admitted of greater precision of movement. It had levers to aid the motion of the screw, and thus economised human labour. In its later developments the Stanhope press is certainly a beautiful machine. We see the form of types laid upon a travelling carriage, which, after the types have been inked, slides back to its place under or within the press. We see a sheet of paper placed upon a parchment *tympan* or drum, a skeleton frame called a *frisket* turned down on the sheet, and both tympan and frisket turned down in such fashion as to exhibit the sheet of paper with one surface exposed (except at the margins around the pages), and having an elastic support beneath it. We see this compound apparatus placed upon the form of type; both moved under the *platten* or heavy plate of the press; a handle worked to give motion to the screw; and all these movements reversed to liberate the printed sheet from its prison.

Numerous have been the minor improvements in the Stanhope press. In some patented presses the form of types remains stationary, while the platten is

removed to permit the types to be inked. In others the pressure is produced entirely by levers, without any aid from screws. But let the press be what it might, its *velocity* of working was confined within a limit which no ingenuity could surpass. Its hourly power of printing was reckoned by hundreds, not thousands, of sheets. And when we come to watch the process of inking the types, we see how this must necessarily be the case. The old printers used inking cushions or *balls*, formed of sheepskin stuffed with wool; printing ink is an oily viscid liquid; the balls, after being dipped into or upon the ink, were worked two together in order to equalise the ink; and the types were daubed over by the two balls. A most clumsy method this now appears to us; yet it was doubtless deemed a capital expedient by the inventor, whoever he may have been. It is still adopted by some printers; but it is slow, and wastes much ink. The method now more frequently employed is to have a roller made of an elastic composition (glue and treacle), which transfers the ink to the type more expeditiously and more cleanly than the balls.

## The Printing Machine, and its Wonders.

But the great, the crowning effort to advance printing has been by the application of the mighty power of steam.

Sixty years have now elapsed since the first attempt to produce a printing machine which should economise hand labour. Mr. Nicholson took out a patent in 1790, for a machine which—in theory, if not in effect—bore a strong resemblance to the last refinement in printing apparatus; for he proposed not only to distribute and apply the ink by cylinders, and to place the paper on a cylinder, but also to arrange the type on a cylinder, as in the most recent of Applegath's machines. Whether this machine ever went beyond the patent, whether it was ever in actual work, we do not know; but it may be concluded that practical difficulties interfered with the general introduction of the machine. More than twenty years afterwards the composition inking-rollers were brought into use; and a plan was suggested by Messrs. Donkin and Bacon for arranging the types on oblong prisms. In 1814 the first notable advance was made, by the introduction of König's machine into the *Times* printing office; on the 28th of November in that year the readers of this celebrated journal were informed that the printing of that day's broad sheet had been effected by a steam-worked machine; and the (then) astonishing speed of eighteen hundred copies per hour was stated to be within the capabilities of the machine. It was quite right that the proprietors should speak in a gratified tone of their achievement; for it was one which greatly increased the power of the daily journals, and which laid the foundation for subsequent advancements.

More than thirty years ago Mr. Cowper, who has been one of the most untiring investigators in this department of mechanical art, invented improvements which, though not exactly printing machines, were component parts of the machine method. He made a machine for printing from curved stereotype plates; he made a machine fitted for printing books from ordinary types; and he introduced the system of inking now in general use. But it was in 1827 that Mr. Cowper, in conjunction with Mr. Applegath, made the signal improvement which enabled the *Times'* proprietors to print five thousand copies per hour with one machine. This is the printing machine, improved in minor details by various inventors, which now constitutes the most powerful working agent in our principal printing offices; it sets four paper-cylinders and four inking-rollers to work at once, instead of one of each, and thus quadruples, or nearly quadruples, the productive power.

The printing machines now employed at most of the large establishments in this country exhibit a harmony of movement most striking. Steam gives motion to the whole; but how numerous are the concurrent movements into which this motion is broken up! There are shafts and riggers, bands and spindles, wheels and axles, cogs and pinions, ratchets and levers, cylinders and rollers—all the paraphernalia of the machinist's labours; but it is not until we trace the numerous delicate and precise movements which these bring about, that we can appreciate the control which the master-power—steam—exerts on the whole assemblage. Several things are being done at once. While one form of types is being inked, another is impressing a sheet of paper; while one sheet is being thus impressed, another is travelling along to prepare for a similar process; while one set of inking rollers is doing its work, another is supplying itself with a coating of the unctuous compound.

Let us see whether a few words may suffice to convey a general idea of the action of such a machine. First for the inking. The thick ink is placed in a reservoir, in contact with which rotates a roller called (we know not why) the *doctor;* by which this doctor becomes thoroughly coated with the black oily compound. Another roller, having a peculiar vibrating motion, touches the doctor at intervals of a few seconds, and robs him of a little of his ink, which it transfers to a flat iron table; other rollers spread the ink evenly over the table; and another set again feed their surfaces from this table, and spread the ink over the form of types, by rolling along it. All this is very curious; for the ink becomes diffused in a remarkably even manner by these numerous transfers from surface to surface. Meanwhile the paper has not been idle. A boy, perched up on high, places a sheet of paper on an endless web or apron; the sheet is caught in between a cylinder and a row of tapes, and thus passes on from one cylinder to another until it leaves the machine. But in its progress it is exposed to two printing processes. When one surface is downwards, it is pressed or made to roll upon one of the two forms of inked type, by which the sheet is printed on one side; and then after two or three serpentine twistings—over one cylinder and under another—the other side of the sheet is brought downwards, and is made to roll over the other inked form of types. How to adjust the cylinders and the tapes, so that the sheet shall not be crookedly printed; how to arrange the 'doctor' and the other rollers so as to apply just enough ink and no more; how to make the type-form go and fetch its own ink, and return to the exact spot at the exact time; how to make the sheet of paper, in its travels over and under about half a dozen cylinders, present each surface exactly at the proper instant to the proper inked form—how to realise all these conceptions, has been a tax to the inventive powers of our Applegaths and Cowpers; but the result shows how triumphantly they *have* been realised.

Great as these achievements unquestionably are, however, the *Times*' printing machine of 1848, and the *Illustrated News*' machine of a later date, are still greater marvels in the art. To what pitch the speed of printing will ultimately arrive, it would be vain even to guess; but these *vertical* cylinder machines seem to have a power of expansion (so to speak) which will lead, step by step, to further increase of efficiency. As it was the *Times* which introduced König's machine in 1814; as it was on the *Times* that Cowper and Applegath's improved machine first exhibited its powers in 1827; so was it the same journal that enabled Mr. Applegath to display the wonders of his new conception in 1848, by printing eight or nine thousand copies of that newspaper in an hour.

If we were about to attempt a minute description of this new machine, we should at once ask the reader to suppose the large cylinders of an ordinary printing machine to be turned up on their ends, and to be revolving on vertical instead of horizontal axes; and further to suppose that the types are arranged round a cylinder, instead of being packed together on a flat surface—for these are the two pervading principles of the new machine. And though we cannot go into technical details, a recognition of these two principles will do much to render the action of the machine intelligible. The monster machine at the *Times* office, then (for it is this of which we are speaking), has the type ranged round the surface of a cylinder more than five feet in diameter; or, more correctly, the surface is a polygon, each side of the polygon being equal to the width of a column. This type cylinder rotates, and presents its several polygon facets to the sheets of paper. The inking rollers are vertical, and they feed themselves from a reservoir, which is also vertical. There are eight cylinders, about a foot in diameter, round each of which a sheet of paper coils itself; eight boys place the sheets upon stands or platforms, and the eight sheets are drawn down and made to wrap round the eight cylinders. The inking rollers receive their dose of ink; they touch the types as the type cylinder rotates; the paper cylinders press the paper against the inked types; the printing is effected before the spectator can well tell what has become of each sheet; and the eight printed sheets fall from the eight cylinders, and are received by eight boys who are seated at the lower part of the apparatus.

In this most beautiful machine, Mr. Applegath undertook to provide a power adequate to print 8000 copies per hour; but he conceived it probable that, by a few slight improvements, such a machine might attain a speed of 10,000 or 11,000; and some such increase has been obtained.

It was a pity that a larger amount of 'standing room' had not been afforded around the *Illustrated News* printing machine at the Great Exhibition; many an eager eye wished to trace the movements of the mysterious cylinders, but wanted facilities. Yet was it such an opportunity as was never before afforded; and those who *did* watch the machine attentively know more than any written description can tell them. When the increasing circulation of the *Times* rendered it necessary to expedite the process of printing; when the proprietors requested Mr. Applegath to tax his skill in producing a machine which would print eight or ten thousand copies in an hour; when Mr. Applegath surmounted all the difficulties; and when the means of accomplishing this typographical feat was rendered apparent;—then did the proprietors of that paper commission Mr. Applegath to make for them the machine which was fitted up in the 'machinery in motion' department of the Exhibition. This machine is smaller than that of the *Times;* it has four cylinders instead of eight; and these four cylinders have a united surface exactly equal to that of the type cylinder. How the paper takes its extraordinary tour among the cylinders; how the 'laying-on boy' places the sheet upon a little platform, and a spindle urges it from the platform towards vertical tapes, and the vertical tapes transfer it to the care of upright bars of wood, and the bars of wood transfer it to small pulleys, and the small pulleys resign it to marginal tapes while the sheet is being pressed against the type, and the marginal tapes dismiss it to the care of other little pulleys, and the 'taking-off boy' finally receives it from these pulleys—how all this is effected is, perhaps, not "more easily conceived than described," but it is certainly beyond the descriptive scope of the present work.

So valuable is every minute in printing a daily newspaper—especially such

as the *Times*, which now sells something like forty thousand copies per diem—that the amount of power required is quite extraordinary. Besides two of Applegath's great eight-cylinder vertical machines, there are three of the older four-cylinder horizontal machines in the *Times*' office. There are nearly a hundred and fifty compositors and pressmen employed in the evening and night. The types in constant use weigh no less than seven tons. Each day's impression consumes about four or five tons of paper, presenting a printed surface of thirty acres, much exceeding the area of the Crystal Palace. One copy of the *Times*, including a four-page supplement, contains nearly a million types. There have been more than fifty thousand copies printed in one day, at a period of great political (and consequently news-reading) excitement.

Whether printing will ever be done by the furlong or the mile is a question destined (probably) to receive an answer ere long. When paper was rendered capable of production in endless lengths, it naturally became a speculation whether printing could not be conducted *before* instead of *after* the cutting of this paper into sheets. Some slight approaches to this method have been made; and patentees are looking out sharply in the same direction. Mr. Rose, of Glasgow, for example, patented such a machine in 1849. In his machine there are two horizontal cylinders, with the type arranged on their surfaces, one for each side of a newspaper or sheet; there are ink-supplying, ink-distributing, and printing rollers ranged around each of these cylinders; an endless web of paper is drawn through both machines, printed on both sides; and a cutting apparatus severs it into sheets after it leaves the machine: there are thus required no 'laying-on' boys or 'taking-off' boys. Such at least is the specification of the patent; and, whether this particular machine has been found available or not, there can be little doubt that something of analogous character will astonish the world before long. Mr. Bodmer obtained, about the same time, a patent for an invention almost identical in object with Mr. Rose's, but intended to print two webs of paper at once instead of one. Again, in 1850, the ingenuity of Mr. De Witte was shown in a patented machine for printing endless webs of paper from cylinders having stereotyped surfaces.

But there is something more than mere unapplied patents, in respect to these vertical-cylinder endless-printing schemes. Mr. Hoe, an American inventor, patented, in 1848, an application of the vertical cylinder arrangement; and about the same time the *Times* gave the following paragraph:—"Mr. Moreton, an American printer, died lately in Paris. He has bequeathed 40,000*l.* to be given as a premium to anybody who shall succeed in constructing a machine capable of striking off 10,000 copies of a newspaper within an hour." The *Times* machine does not, we believe, actually exceed 8000 or 9000 at its regular working speed, although it is said in current language to reach 10,000; and the Moreton prize has probably not yet been claimed. Yet it seems that Mr. Hoe's invention is making rapid progress. Towards the close of 1849 the French newspaper *La Patrie* had an article relating to the printing of that journal; it was stated that one of Mr. Hoe's machines, with four vertical cylinders, was then producing 133 copies of *La Patrie* per minute, or about 8000 per hour; that four months' use had well satisfied the proprietors of the journal, and that a six-cylinder machine of similar construction had been ordered, with a printing power of 12,000 copies per hour But the Paris press claims to have outdone both Mr. Hoe and Mr. Applegath more recently. In the spring of 1850 a new printing machine was set up in the office of *La Presse*, invented by M. Worms, a printer of Paris. It con

sists of cylinders covered with papier-maché stereotypes, from which the printing is effected on endless webs of paper. It was asserted at the time that a speed of 15,000 copies per hour was attained—but this is almost "too good news to be true." Indeed, it must be owned, that many such statements in the French newspapers require to be received with caution.

## Printing Establishments, in Modern Days.

Few comparisons would present more curious results than that between a printing office in past days and one in 1851. Everything *was* done by hand, and on the domestic-manufacture system; much is now done by steam, and all on the factory system. Our Clowes, Hansards, and Spottiswoode's, at the present time exhibit the factory system in its best aspects; that is, combination in some departments, subdivision in others. The well-known rapidity with which Parliamentary Papers are got up and printed has been often noticed; and the recent printing of the Official Catalogue of the Great Exhibition was a notable instance of such expedition. We quote a few words from the *Companion to the British Almanac*, for 1852, in illustration of this matter:—"The Shilling Catalogue was classified, numbered, made up, and 10,000 copies printed and stitched in covers—in four days. The first complete copy was not produced till 10 o'clock at night on April 30th, and yet 10,000 were at the Crystal Palace before the arrival of Her Majesty on the eventful 1st of May. Two splendid copies, presented to Her Majesty and the Royal Consort, were bound and gilt in a sumptuous style in six hours."

The French, and foreign countries generally, are more accustomed than the English to form large establishments, wherein the printing as well as the publishing of books is carried on. Perhaps the remarkable freedom of individual efforts in England may tend to explain this difference. The establishment of Alfred Mame and Co., in Tours, is one of those in which printing, binding, and publishing are all combined, and where they have been so combined for nearly half a century past. All the works relate to religious and moral subjects, and undergo a sort of general editorial supervision: such as educational books, sanctioned by the Roman Catholic Church; missals and other books of piety; and educational books for primary schools. The warerooms of the establishment are said to contain a million and a half of small books, pamphlets, and tracts; besides another store in unfolded sheets. There are about twenty machines, worked by steam-power, to carry on such of the printing and binding operations as can be brought within the scope of this power; and these machines are adequate to the production of fifteen thousand volumes per day, each containing ten duodecimo sheets. The sewing, boarding, and binding of the books, occupy many more hands than the printing, being less within the scope of steam-power. It is said that there are no less than one thousand persons of both sexes and various ages employed in this 'bindery' (the innovating but convenient name that our friends across the Atlantic give to a bookbinding establishment), by whom books are bound in styles varying from the most sumptuous magnificence down to the most economical plainness. All the copper and steel-plate engravings introduced into the illustrated works, are also printed in the establishment. It does not appear that type-founding is carried on, and in this respect the Tours establishment must yield precedence to a few great printing firms in England; but the combination of printing, binding, and publishing, on so large a scale, is certainly note-worthy.

Passing to another country, we find the Imperial Printing Office at Vienna, certainly one of the most gigantic manufacturing establishments in the world. The Vienna establishment comprises within its range of operations an astonishing variety, both artistic and manufacturing; and the buildings are necessarily of great magnitude. There are said to be five large masses of buildings, the floors connected by iron and stone staircases, and the buildings connected by galleries. There are steam-engines, nearly fifty printing-machines, more than this number of printing-presses, half as many copper-plate presses, forty lithographic presses, several glazing cylinders, pumps for cold water, boilers for hot water, flues for hot air, eight type-founding machines, ten furnaces for melting type and stereotype metal, gas in all the buildings, speaking tubes from one building to another—all the appurtenances, in short, of a vast printing establishment. And so closely is the progress of science watched, that when a new discovery is made, advantage is immediately taken of any practical availability which may attach to it in respect to the typographical art; thus photography and electrotype are brought into requisition; and any new qualities discovered in gutta percha or other substances are similarly watched with an attentive eye.

Fine art, too, as well as science, is sedulously cultivated at this remarkable establishment. A school for wood-engravers has been established, whence productions of great beauty issue. Colour-printing, among other branches, is conducted with consummate skill.

Nothing could better illustrate the extent and nature of the labours at this establishment, than the admirable display of them at the Great Exhibition. The terminations *graphy* and *typy* never surely had such numerous applications before: *typography*, *xylography*, *chemitypy*, *stereotypy*, *electrotypy*, *typometry*, *lithography*, *galvanography*, *photography*, all were presented to our notice. There were steel punches for type-letters, comprising the characters for more than a hundred foreign languages, besides mediæval characters, and letters for blind persons. There were matrices of Chinese, Japanese, and other peculiar types. There were printed specimens in the principal languages of the whole world. There was the Lord's Prayer, printed with Roman type in 608 languages and dialects, and also in the characters of 206 different nations. There was a copy of Gutenberg's Bible, and specimens of the type used for it. There were copies of books recently printed in the establishment, for various persons, requiring rare or peculiar type. There were large engraved woodcuts, with moulds from them taken in gutta percha, and electro-copper casts from the moulds. There were pictures, *chemityped* or etched on zinc by a chemical process, and capable of being printed at the common press. There were stereotype plates of all the alphabets in the world, with moulds or matrices in gutta percha and in plaster, and electro-copper casts from the moulds. There were numerous electro-copper casts from types, woodcuts, petrifactions, bas and alto-reliefs, &c.; besides admirable plates suitable for engravers, and the really wonderful sheet of copper thirty feet long—wonderful when we bear in mind that it was produced from a cold liquid solution of copper by galvanic agency. There were numerous chromo-lithographic prints, hung by the side of the original coloured drawings, to which they made a singularly near approach in richness and softness of colouring. There were engraved steel and copper plates, and impressions taken from them. There were electrotint plates, in which the subject is produced by painting and galvanizing, without either etching or engraving. There were designs for ornaments connected with books and bookbinding,

and ornamental tools for bookbinders. And lastly, there were a dozen or more of photographs.

Such are some of the points of interest connected with an establishment which is said to employ nearly a thousand persons; which possesses a hundred and fifty millions of letter-types, weighing a hundred and fifty tons; and at which three hundred thousand sheets of paper are printed daily.

The typographical contributions to the Great Exhibition by three societies in London were interesting in an industrial point of view, irrespective of other considerations. The *British and Foreign Bible Society* have printed the whole or portions of the Bible in 170 different languages, of which 118 are from translations never before printed. Specimens of nearly all of these were exhibited, and a most curious collection they made, worthy of more study than casual visitors to the Exhibition could give them. The same Society illustrated the progress of the printing art, by placing side by side Bibles printed in 1816 and others printed in 1851, to show that the paper, printing, and binding had all improved, while the expense of production had lessened 62 per cent. The *Religious Tract Society* have published tracts and other religious books in 110 languages, specimens of most of which were exhibited. It is a striking illustration of the world-renowned position which Bunyan's 'Pilgrim's Progress' occupies, that the Society have printed and published this work in no fewer than 28 different languages.

The third Society alluded to above, the *Society for Teaching the Blind to Read*, occupy a marked and distinct position, from the peculiar object to which attention is directed. The contributions consisted of embossed books, cyphering books, maps, geometrical boards, embossed writing copies, music, and chess boards—all intended for the use of those who have to bear the dread calamity of blindness. The raised characters are in an arbitrary type, formed of curves and lines similar to those used in some of the systems of short-hand; while in the Glasgow Blind Asylum the ordinary Roman letters are employed. All such embossed letters are produced by stamping on paper with bold but un-inked metal types, and the finger of the blind student reads the words as it passes over them. There is something sadly beautiful in this mode of blindly *feeling* the way to knowledge. The cyphering-boards are perforated all over with small square holes, into which types easily fit, and these types represent the ten numerals. In the maps, the land is raised above the water, and great distinctness is given to the lines and spots which represent cities, mountains, rivers, and geographical boundaries. The chess-boards have the black squares raised above the level of the white; the black pieces are distinguished by a projecting point; and all the pieces have pegs which fit into holes in the board. There is also a pretty apparatus by which the blind can print their own thoughts, or write and print at once. There are stamps or punches for the various letters, and these stamps, by the aid of levers, a slide, a bar, and a rack, can be made to impress a sheet of paper in regular lines. The *Edinburgh School for the Blind* contributed in like manner various contrivances which are used in that establishment.

There were some Egyptian books in the Exhibition, which, judging from circumstances, appear to have belonged rather to plate-printing than to type-printing; for the pages were from leaden plates, and had been printed by the lithographic press. The collection was highly interesting; it comprised about a hundred and fifty volumes, printed in the Turkish, Arabic, and Persian languages, and relating to history, military science, medical science, poetry, and other subjects. The paper of the books was manufactured, and all the print-

ing processes conducted, in Egypt; and the display certainly illustrates the marked progress which that country has made under the unscrupulous but sagacious Mehemet Ali.

## Chromatic or Colour Printing.

By little and little the art of printing in colours has arrived at great perfection. One single colour, if well printed, was accounted a feat in bygone times; now, the diversity of colour is almost unlimited. The colour may be mixed with oil instead of with water; and the style of the engraving may be almost any one of those adopted for ordinary purposes.

As to the origin of this kind of printing, it is difficult to attribute it to any one inventor; for the simple use of red ink instead of black would, in effect, be colour-printing. There are found to be initial letters, in some of the very earliest printed books, in two colours; these must have been printed at two operations, with ink of two colours. At various times during the last three centuries modes were adopted of producing engraved pictures, not exactly in colours, but in light-and-shade, as if copied from drawings in India-ink or in sepia. Mr. Savage's Treatise on Decorative Printing, published rather more than thirty years ago, was one of the first works which gave an impetus to this beautiful art. The fancifully-adorned lottery-tickets (of which the present generation know little, except by tradition) were, under the inventive talent of Mr. Whiting, made another of the means for introducing colour-printing; not pictorial, but typographical. It is not a little remarkable that *playing cards* (which were among the means of introducing woodcut printing four centuries ago) gave also an impetus to the art now under notice. In a former number of this series we have described the mode of making these cards, and have stated that, by Messrs. De La Rue, the cards are printed in *oil*-colours. Now it was only after numerous trials and much expenditure that Mr. De La Rue, about twenty years ago, devised a mode of mixing and applying oil colour which would bear the polishing processes necessary to the finishing of playing-cards. This card-colour printing has been the basis of many subsequent improvements in the art.

Another curious example presents itself to our notice, showing that humble productions illustrate a principle as efficiently as those of greater dignity or rank. Let us select the label of a *blacking-bottle* as an example of a notable advance in colour-printing. We must, of course, begin by duly acknowledging the unrivalled merits of "Day and Martin's incomparable jet;" no matter whether Day is dead, or Martin dead, or both; no matter whether Day and Martin have had merely a hypothetical existence, like Boz's "Mrs. Harris"—it is sufficient to know that this "inestimable composition," has a large sale; and we are further justified in believing it possible that roguish traders (for there may be rogues in blacking as well as rogues in grain) might imitate the label, as a means of sharing in the profits of this "real japan." Now if such were the case, the manufacturers would have a strong inducement to employ a label which would be very difficult to imitate; and this, we believe, is the true history of the colour-printed label found on the bottles sold by the firm in question. It must have been indeed an achievement when that production was brought to light in the infancy of colour-printing. How to produce the lace-work ground-pattern in red ink; and the waving lines in red and black ink; and the white and black and red letters of varied sizes and shapes; and the woodcut of the ambitious Ionic-columned factory in Holborn; and

the copied autograph of the veritable Day and Martin—how to effect all this called for much patience, skill, and expenditure of capital; and a department of the establishment has been expressly set apart for this purpose. A cylinder machine, on Mr. Cowper's principle, is employed, with two cylinders, one for red ink, and one for black—each cylinder being large enough to print eight labels at once. For each label two stereotype plates are prepared, by a combined process of casting, stamping, and modelling; they are so accurately adjusted, that every raised spot in one plate corresponds with a sunken spot in the other. One plate contains, in relief, the whole of the letters and devices which are to be printed in black; while the other contains those for red; and both plates are bent to the exact curvature of the two cylinders. Eight plates are adjusted to each cylinder, with great accuracy; and the inking rollers are so placed that the inking of the black plates is completed just as the paper is brought near; while the red plate is similarly brought in readiness to seize and impress the paper directly it is liberated from its neighbour. The more completely the black and red portions are seen to keep clear of each other in the label the more accurate must have been the adjustment of the plates on the cylinders.—Thus the "pursuit of knowledge" may lead us even to the study of a blacking-bottle.

About the year 1836 Mr. Baxter procured a patent for a method of printing in oil-colours, from wood-blocks and steel-plates conjointly; and this method has recently been carried to a degree of considerable excellence and beauty. Some specimens of oil-colour printing are from wood-blocks only; while others are worked by the woodcut method, from mezzotinted metal plates, of which as many are used as there are tints in the picture.

It is scarcely possible to conceive a higher degree of beauty than now distinguishes some of these colour-printed productions. The names of Baxter, Hullmandel, Hanhart, and many others, among the patentees and printers, and those of some of our best artists among the draughtsmen, are becoming every day better known to the purchasers of cheap but good artistic productions; while every kind of pictorial subject, and almost every style of engraving, are being brought within the range of colour-printing. We have copies from the old masters, and copies from the Stanfields and Creswicks of our own day; we have graceful story-book illustrations by Absolon and others, and sumptuous decorative ornament by Owen Jones; we have fruit and flower pieces in imitation of Nature's work, and buildings and other productions of man's industry. All these are depicted or designed on engraved steel, on mezzotinted softer metal, on stone, on wood, or on stereotype plates; and all are alike brought within the powers of the colour-printing press. Nor do these productions belong exclusively to the domain of fine art; the colour-printed paper covers for cheap books, with their glazed surfaces, are not only pleasing to the eye, but are more durable than the paper garments of the books published "in boards" in the olden time; while they are cheaper than cloth binding.

It was one of the most instructive characteristics of the Great Exhibition that, whenever opportunity offered, the successive stages of any particular process were represented in their proper order. Such was the case, among other instances, in respect to colour-printing. In the Saxon section, this art was illustrated by a series of sheets, each exhibiting one stage in the chromo-printing process, showing how many times the print itself had to pass through the press before its final completion. And thus likewise were the productions and processes of Mr. Baxter illustrated.

The application of colour to lithographs is among the beautiful novelties of recent times. It can scarcely be necessary here to describe a lithograph, or to state that it is printed from stone; but a few words will suffice to show the relation between a *woodcut*, an *engraving*, and a *lithograph*. A woodcut is printed from *raised lines;* an engraving is printed from *sunken lines;* a lithograph is printed from *chemically-prepared lines*. A wood-block is cut till none of the surface is left except the lines which are to be inked and printed; whereas an engraved copper or steel plate is so cut or engraved that the parts left shall be un-inked in printing. A lithograph differs considerably from both. A stone of a very peculiar quality, brought chiefly from the Danubian provinces, is carefully prepared on the upper surface. A design is sketched on the stone, either with lithographic chalk or lithographic ink—both of which are nearly alike in composition, but one is used dry and the other wet. A solution is poured over the stone to fix this device; and when about to be printed, the stone is sponged with water, which is received by the stone but repelled by the chalk or ink. The printing ink, applied by a roller. is repelled by the damp stone, but received by the device, and a press suffices to effect the transfer.

Such, then, is ordinary lithography. The *lithotint* and the *stump drawing* on stone are two methods of colour-printing practised by Messrs. Hullmandel, and of which some beautiful specimens were displayed at the Great Exhibition. Many of the specimens in the first of these two styles were drawn on the stone by Cattermole, Harding, Haghe, and Nash. They are executed by making drawings on the stone with a liquid ink applied by a brush; the quality of the ink being such as to resist the action of the chemical agent afterwards applied to the stone. The result produced has much of the beautiful effect presented by an original drawing in sepia colour. It is a style considered to be well adapted for engravings relating to engineering, architecture, and natural history, The other of these two methods, the *stump* drawing, is effected by applying the stump to designs which have been produced partly by chalk and partly by ink. The method of *lavis aquarelle*, or water-colour wash, employed by some of the French lithographers, seems to bear some resemblance to the English lithotint.

## Mixed Processes, in Modern Printing.

It is a matter full of instruction, in respect to the probable future of this valuable art, to watch the various combinations which are now going on, in respect to principles, materials, and processes. Engraving, lithography, xylography, stereotyping, black printing and colour printing, casting and pressing, electrograph and photograph, metal and stone, wood and paper, gutta percha and bitumen—all are being brought to afford mutual aid, each to each. The lines of demarcation are being broken down; and we are, every month or two, called upon to attend to some new and ingenious process, which, if called by a correct descriptive name, would indeed require a complex assemblage of Greek syllables.

Some of the recently-introduced modes of engraving or preparing designs of any kind for the press are really remarkable. One example, shown in the French department of the Great Exhibition, is an expeditious mode of engraving maps. It is always desirable to have some distinctive mode of engraving an uncoloured map, so that the eye shall catch readily the boundaries between land and water. In the example in question, a very delicate

machine makes lines of dots over the whole of the *land* portion of the map; the dots are very faint, and very close together, so as to form a sort of tinted ground; the machine is said to make two thousand dots in a minute; and, by a beautiful contrivance, it reverses its action whenever it encounters the deeper lines which mark a boundary between land and sea.

Another novel kind of printing is a combination of typography and lithography. Part of a page is set up with ordinary moveable types; an impression from them is transferred to a lithographic stone; the remainder of the design or page is filled in by drawing on the stone with the usual material; and the stone is then prepared for printing in the usual lithographic method. This double system is intended for application in bordered, tabular, or ornamental printing; and it seems to be capable of useful extension—since the precision of type-printing may be combined with the artistic grace of lithography. Another kind of litho-typography, of French invention, is a peculiar mode of etching upon stone, so as to leave a printing surface raised considerably above the general level of the stone.

There were specimens exhibited of a new art, to which the embarrassingly-learned name of *panëiconographic* printing was applied. It seems to be an attempt to combine the excellencies of all kinds of engraving, by producing plates in which the design, though always raised or in relievo, has sometimes the characteristics of one style, sometimes of another. The French exhibitor of the specimens, in his catalogue-description, says that this panëiconographic art has the power of "reproducing on every kind of metal (whether engraved or in relief) any lithographic, autographic, or typographic print, any drawing in pencil or in stump, any engraving on wood, steel, or copper, whether produced by aquafortis or by the graver, in such manner as to be able to print these reproductions by means of the typographic press." The typographical or common printing-press is so much more expeditious in its operations than the copper-plate or the lithographic press, that it would be a valuable improvement if all the various kinds of engraving really could be reproduced by such means—whether or not we give a hard Greek name to the process which ensures this result.

The Denmark section, which was not very large or important, contained, nevertheless, a specimen of a new art, which the exhibitor, M. Schöler, calls *stylography*. It is said to be a method whereby a copper-plate can be engraved without the aid either of the graver or the etching-acid; and M. Schöler exhibited an engraving in all the various stages of progress. In the first place a smooth metallic surface is prepared; on this surface an even layer of black composition is cast; on this composition a thin coat of silver is applied; on this silver the artist sketches his design with a sharp-pointed instrument, cutting deep enough to expose the black composition beneath; from this black and white picture (for such it certainly is, the black lines of the design being visible through a silvery ground) a copper cast is taken by the electrotype process; and from this cast a second cast is produced by the same process, which becomes of course a copy of the silvered composition model. From the copper cast last produced impressions may be taken by the ordinary copper-plate press. This is one of many modes of applying electro-deposition to the production of engraved plates; but it must require very careful manipulation to produce by these means a plate flat and perfect enough to meet the exigencies of a press.

Bank-note requirements, as is well known, have led to many curious and valuable inventions, in respect both to paper and printing. There is Messrs. Perkins

and Heath's method, by which one process of engraving suffices for an unlimited number of impressions, by a transfer of the device from hard to soft steel. There are Mr. Oldham's numbering machines, as used at the Bank of England, whereby bank-notes may be numbered consecutively with unerring accuracy and great facility. There is a method, patented a few years ago, but not (so far as we are aware) yet acted on, for a very peculiar mode of printing bank-notes; a groundwork of geometrical figures is printed with an ink of a certain chemical character; another design, different from the former, is printed with a different colour, and the note is then printed with the usual entries—thus presenting many chemical obstacles to imitation or transfer. There is the United States' patent for bank-note paper, in which the number of threads introduced into each piece of paper is made in some way to indicate the number of dollars for which the note is current. There was Mr. Fisher's bank-note paper, shown at the Great Exhibition, prepared for receiving black letters on a neutral-tinted ornamental background, from which a signature in common ink could not be erased without changing the colour of the ground. There was Mr. Saunders's 'white and coloured safety paper' for bank notes, bankers' cheques, letters of credit, &c., capable of detecting the removal of writing by any chemical agent.

It is in relation to chemistry, or chemical affinity and repulsion, that we ought to regard the *Anastatic* printing which made such a commotion a few years ago. In 1841 the world was startled with this new art—this handbook of forgery or of stealing, as some would fain have deemed it; in 1851 we hear little of it. It is certainly a remarkable process, depending mainly on the antagonism of oil and water. A printed sheet of paper is moistened with dilute phosphoric acid, and is pressed on a clean surface of zinc; and by this contact the acid of the unprinted part *etches* the zinc beneath, while the printed part *sets off* on the zinc. There is thus produced a reverse copy of the printing on the zinc. The plate is washed with an acid solution of gum, and is then inked: the affinities in some instances, and the repulsions in others, cause the lines of the device (whatever it may be) to take the ink, but the other parts of the plate to remain clean; and the printing then follows. This Anastatic method of printing has gone a little, and only a little, beyond the limits of a manipulative curiosity. Mr. Cowell, of Ipswich, has published a 'Descriptive Account' of the process, with illustrative specimens and practical instructions. The claims put forth for the method are somewhat comprehensive; for it is averred that "designs produced either by the ordinary process of printing from types, copper or steel plates, wood, stone, &c., or by the manual operations of writing or drawing in prepared ink or chalk, may be readily transferred to the metal plate, and an indefinite number of copies produced, at a really trifling cost." The time has not arrived for determining the real commercial and artistic value of the art; yet a marked and distinct value it assuredly will have, for it is one of the most peculiar modes of *copying* ever devised.

*Photography* or *Daguerreotype* seems to belong so much more nearly to Fine Art than to the printing art, that its claim to a place in the present sheet is not quite indisputable; still, as we wish to show the bearings which the numerous family of 'graphs' and 'types' have one towards another, a few words relating to this curious art may be desirable.

To paint a picture by a sunbeam is certainly a beautiful art; but to give permanency to the picture has required all the resources of modern chemistry. Like every other art, the progress of improvement has been gradual, from small beginnings to splendid results. The old alchemists knew that certain chemical

substances turned from white to black by exposure to the sun; but they did not seek out the cause of the change. The chemists of the eighteenth century went farther; and Wedgwood and Davy advanced yet another stage; but it was M. Niepce, a Frenchman—first by himself, and then in conjunction with M. Daguerre—by whom the fixing of the sun-pictures was first effected. In 1839 Daguerre publicly announced his discovery that iodide of silver is an exquisitely sensitive material to act upon, and that the vapour of mercury tends to develop and fix the image formed by light on the iodide. Most curiously, our own countryman, Mr. Fox Talbot, was working on the same kind of experiments at the same time, without any knowledge of the Frenchman's labours. As in the great planetary discovery by Adams and Leverrier, so in this case—an Englishman and a Frenchman were working simultaneously, in the same direction, but each in ignorance of the other's labours; and in each case the Frenchman, by priority of publication, has carried off the lion's share of popularity.

The last twelve years have presented a continuous chain of improvement in this most attractive art. Scientific men, practical chemists, artists—all have added to our stock of information on the subject. And the distinctive names, too, have been wanting neither in number nor in variety. Besides the designations drawn from the names of the inventors, such as *Daguerrotype*, *Talbotype*, *Hillotype*, and the like, we have many other 'graphs' and 'types' such as *photograph*, *heliograph*, *calotype*, *chrysotype*, *amphitype*, *chromatype*, *cyanotype*, *ferrotype*, and two or three others. Most of these designations depend upon the kind of chemical substances employed.

The photographic principle has scarcely yet become an accessory to the printing art. There is evidence, however, that it may become so ere long; for, by a most delicate and beautiful manipulation, an electrotype cast has actually been taken from a photographic plate, and an impression printed from it—a sunbeam paints a picture, and a galvanic current engraves it. Proofs have also been given that photography may become a handmaid to the printing art; for many scenes and views have been presented in various illustrated ournals, which could not have been published in time but for the quick mode in which the sketches are produced by photography.

The *processes* of photography are varied and often difficult; but their rationale is simply as follows:—A prepared surface of metal, paper, or glass (the mode of preparation being varied according to the material), is placed in a camera obscura; the object to be copied is placed before an opening in the camera; an image of the object becomes focalised on the prepared surface; the strong lights and the faint lights act differently on the chemically-prepared surface; and by subsequent processes the parts thus differently affected become developed into a picture, which another process renders permanent instead of evanescent

Slowly but surely does the printing art become linked to Fine Art on the one hand, and to science on the other—a tripartite association such as Industry is developing around us on all sides.

# COTTON AND FLAX: A CONTRAST.

A COMMERCIAL rivalry has commenced; *cotton* and *flax* being the competitors. Flax took the lead in the spinning and weaving districts of England until the days of Hargreaves and Arkwright, when machinery gave an advantage to cotton manufactures which eighty years have not sufficed to disturb. Flax is now advancing again, and its uses are extending; it is well, therefore, to know what are the claims, the merits, the relative strengths, of the two rivals.

The contrasts between cotton and flax are very marked, and meet us in every aspect. Cotton is taken from the seed-pod of a plant; flax is the fibrous envelope of a stalk. Cotton is nearly all grown by slave-labour; flax by free labour. Cotton is grown more extensively in warm climates than in cold; flax more in cold than in warm. Cotton sends nothing to market but the downy fibres; flax sends its whole bulk to the rippling, breaking, and scutching machines. Cotton is gathered in small tufts from the standing plant; flax is pulled up, stalk and all. Cotton is prepared for the manufacturer almost wholly by dry processes; flax requires steeping and wetting in many ways and at many times. The bulk of our cotton comes to us across the Atlantic; the bulk of our flax crosses the German Ocean. Our colonies would send us, of the two, more cotton than flax; our home counties supply some flax, but no cotton. The cotton fibre, microscopically viewed, is a flat ribbon; the flax fibre is a hollow tube. Cotton is rarely manufactured in the districts where it is grown (except by the primitive hand-method of India); flax is manufactured in all the flax-growing countries. Cotton takes rich dyes and colours; flax receives them less kindly. Cotton is suitable for soft and warm woven goods; flax fabrics are harder, colder, and stronger. Cotton adapts itself to machinery in every part of the manufacturing processes; flax is much more difficult to manage by automatic agency, though our manufacturers are gradually bringing it to obedience. Cotton affords no room for home-labour in the earlier operations; flax *might* employ scores of thousands in Britain, before the fibre itself reaches the flax mill.

We might carry on this list of contrasts to a greater length; but enough has been said to characterise the antagonism. There is now, however, an antagonism of another kind, arising not so much from the qualities of the two plants, *per se*, as from the relation in which English manufacturers find themselves placed to the growers of these plants. The cotton world is a little uneasy as to the future supply of raw material; the flax world offers to do what cotton cannot, and is even bold enough to challenge cotton for the leading position. In order to jot down a few of the "curiosities" presented by this large and important subject, we will first take a general glance at the cotton manufacture, and then at that of flax, without attempting any minute detail of operations.

## Cotton: Whence we Obtain it, and How.

Every one now knows that cotton is a soft, white, woolly, fibrous substance, which is brought to England in masses; and that the fibres are disentangled, straightened, and made to join smoothly and regularly into a yarn or thread; which thread is then woven into one or other of many different kinds of cotton cloth. Every one knows, too, that the operations on these delicate downy fibres constitute one of the largest departments of British industry; but there are few readers who know *how* large.

Most marvellous, indeed, is the magnitude of these operations. The quantities and weights which denote the present state of our cotton manufactures are so startling, that nothing but a concurrence of evidence from all quarters could render them credible. That we work up into yarn nearly two million pounds of cotton *every day*; that we have twenty million spindles, whirling their rapid course in spinning this cotton into yarn; that a quarter of a million power-looms, besides hand-looms, are employed in weaving so much of this yarn as is not exported before weaving; that we have two thousand factories in which this mass of cotton is spun and woven; that between three and four hundred thousand persons are daily employed within the walls of these mills, besides those elsewhere employed in various departments of the manufacture; that the machinery of these mills requires eighty thousand horse-power of steam and hydraulic agency; that, after supplying the home demand in 1850, we exported woven cotton goods to such an extent as would give an average of nearly four million yards (far beyond two thousand miles) *every day;* that, besides this, and besides cotton lace and hosiery, we exported nearly half a million pounds of unwoven cotton yarn per day;—that all this is true, we have evidence of various kinds, but especially an elaborate Report prepared for the House of Commons a few months back.

The numbers and quantities in respect to the flax manufacture are much more humble. The flax mills in the United Kingdom number about four hundred, within which seventy thousand operatives are engaged; and to work the machinery of these mills about fourteen thousand horse-power agency of steam and water is required. After supplying our own wants in 1850, we were able to spare to foreign countries three or four million yards of linen (in the year); besides linen lace, thread, and yarn, to the value of about a million and a quarter sterling. It is singular, that, while so many contrasts are presented by our manufactures in cotton and flax, there is so close an analogy in respect to the *personnel* of the factories. The average number of operatives in all our cotton factories is almost exactly equal to the average in all our flax factories; this number is about 170. In the supply of moving power and of spindles to factories, the ratio is higher for cotton than for flax; while the *weight* of material worked up by each operative is greater for flax than for cotton, owing to the relative stoutness and solidity of linen goods. Of cotton-mill operatives, Lancashire has twice as many as all the rest of the United Kingdom taken together; of flax-mill operatives, Ireland claims more than England, and Scotland more than Ireland—the ratios being nearly as 19, 21, and 28.

Such, then, being the enormous scale of our operations in connection with the cotton manufacture, many important questions start up; and these questions now stand forth so broadly, that they *must* receive answers, let the respondents be who they may. Is the growth of cotton sufficient for our wants?

Is it likely so to continue? Is our supply at the mercy not only of climate and weather, but of politics and trade-tariffs? Are any of our colonies within the cotton-growing latitudes; and do they grow cotton; or *can* they grow it and if not, why not?

These questions, and others of similar tenor, have been agitating the manufacturing world pretty extensively within the last two or three years. It is scarcely a figure of speech to say that the prosperity of Manchester and the whole of the Lancashire district hangs upon a cotton fibre. Cotton has made Manchester, and made Liverpool. Cotton has brought up, if not given birth to, Ashton and Stockport, Bury and Burnley, Blackburn and Oldham, and the whole range of cotton towns. Cotton made the Bridgewater Canal; and then it made the first great passenger railway. Cotton created the great engineering machinists of Lancashire, who learned their trade by making looms and spinning machines, and then steam-engines to drive those machines. Cotton taught us the complete theory of the factory system—a good or an injury according to the mode in which it is conducted. Cotton has given us some of our greatest capitalists and a few of our greatest statesmen. Cotton has raised our foreign commerce to a gigantic height. Cotton enabled us to dare a Napoleonic war in past days, and is helping us to pay the never-ending expenses accruing therefrom. Everything that affects cotton affects Lancashire. We may almost assert that every wind that blows upon, or rain that saturates, a cotton field in America, is felt in Lancashire. There is a sensitive barometer always at work; its degrees are marked by eighths of a penny; and the price of a pound of cotton is raised or lowered one or more of these degrees by causes seemingly most remote How many million bales will America produce in the next crop?—is a question which finds entrance into all the commercial arrangements of Lancashire; for the profits of manufacture will depend upon the extent of sale, and the extent of sale will depend upon price, and price will depend upon the price of cotton, and the price of cotton will depend upon the abundance or deficiency of the American crop—all this is, of course, not strictly the case; but it will serve to indicate the nature of the connection between the cotton fields of one country and the cotton mills of another.

The above picture could not be faithful unless America were beyond all question the *great* source of our cotton supply. This she undoubtedly is; and hence we are virtually dependent on that country in respect to this important material of manufacture. For the last two or three years we have imported upwards of seven hundred million pounds of cotton per annum, of which no less than four-fifths are derived from the United States; India, Brazil, and Egypt supply nearly all the remainder. The average price of all the cotton imported was about 6*d*. per lb. in 1849, and nearly 8*d*. in 1850—a most momentous increase this, considering the quantity of material to which it applies. The bags, or bales, which bring over the cotton contain on an average about 400 lbs. each; about eleven-twelfths of the whole quantity are worked up and spun in this country, while one-twelfth is re-exported for manufacture in other countries. Sometimes a greater weight of cotton is worked up in one year than in others, from causes irrespective of the actual briskness of trade; there is at times a demand for heavy goods rather than light, or there is a state of the market in which the former pay better than the latter. In some woven cottons the material is worth twice as much as the labour; while at the opposite extreme there are fine and delicate goods in which the labour is worth twelve or fifteen times as much as the material;

and thus it results that the consumption of cotton may be greater at one season than another, without any increase in the money-value of the goods produced. The ratios differ still more widely in respect to unwoven yarn: in the very coarsest yarn the value of the cotton may actually amount to three-fourths of the selling price of the spun goods; while in the exquisite products of the 'fine-spinning' mills the value of the material may be only one-twentieth, or even much less—so much more largely does *labour* than *weight* enter into the selling price of these articles. More than 1300 lbs. of cotton could be worked up in making the coarse No. 20 yarn, in the same time that would be required for working up 224 lbs. in making fine No. 60.

It will be seen from the above details, that if the price of cotton greatly increase, it will affect the manufacture of coarse goods more sensibly than fine; and hence it is found that when the American crop is small, and the price consequently raised, our heavy cotton goods can with difficulty find a foreign market.

The American crop may be *under* an average, but it cannot be far *over* an average; for the planters always cultivate as much as the slaves can pick; and as the slaves do not rapidly increase in the United States, there is (virtually, seeing that our main supply is from thence) a commercial limit to the quantity brought to market.

During the last ten years, the United States crops have varied from 1,600,000 to 2,700,000 bales; in most years it does not depart far from 2,200,000. About three-fifths of all the United States crop comes to England, the remainder being either taken by the continental states or spun and woven in America. The crops in the four years 1847-50 were scarcely greater in the aggregate than those of the four years 1843-46; while the spinning and weaving power was very much greater. Hence it is now an unquestioned fact that the consumptive power not only treads upon the heels of the productive, but has overpassed it. The United States crop of 1850 was relatively small; and this raised the price so significantly that our manufacturers actually paid 7,000,000*l.* or 8,000,000*l.* *more* for their cotton in that year than would have been paid had the advance of price not occurred.

Lancashire is put to its wit's end to devise a mode of escaping from this perilous dependence on the United States. What other countries contribute to our supply; and can they be made to contribute more extensively? *India* grows cotton somewhat largely; but the cotton is neither so long in the staple nor so clean as that of America, and is hence not so much coveted by our manufacturers. The consequence is, that the price which India cotton obtains in the market is scarcely high enough to pay for cultivation and for freight to England. Besides the shortness of staple and the dirt of the cotton, the India produce is less per acre than the American; and the Hindoos require a large supply for their own cotton dresses; so that, all things considered, many persons doubt whether we can have a largely-increased supply from our Indian possessions. *Egypt* sends us a little cotton, but that little does not appear as if it would become much greater. *Natal*, and other districts in Southern Africa, give some promise of fitness for a cotton crop; but Colonial-Office troubles and Kaffir warfare do not throw a very bright gleam on those regions. *Liberia*, near Sierra Leone, is said to possess the soil, the climate, and the kind of inhabitants fitted for the culture; but the future must tell its own tale as to the truth of the report. *Australia*, according to Dr. Lang, contains many districts where cotton may advantageously be grown; but there will be very little tendency to think of such slow-paced, jog-trot industry,

while the copper of Burra-Burra and the gold of Ophir are glittering in the eyes of the colonists. *Brazil* sends us about 100,000 bales of cotton in a year; but as any great increase must come from the interior, and as roads and steam navigation are sadly neglected in that vast country, many years must elapse before any notable advance can be made. The *West Indies* comprise islands and districts which are better fitted for cotton than for sugar culture; and now that the artificial prop to the sugar trade has been removed, many persons think that a cheering prospect may be afforded by cotton. The great doubt is, whether *free* negroes will consent to work so heartily as to enable our West India planters to compete with the *slave*-negro labour of the United States.

## Our Cotton Mills, and their Characteristics.

In whatever country cotton is grown, the mode of culture is nearly alike. The cotton tree is a herbaceous plant, usually from four to six feet in height, varying according to circumstances of soil and climate. Very little attention is paid to any part but the seed-vessel, which is a capsule containing three, four, or five lobes; in these lobes are many seeds enveloped in cotton fibres. When the so-called "Ethiopian" songsters tell us of their heroes and heroines "pickin' cotton in the fiel'," they are thus far right; the cotton *is* picked in the field, and the tree left standing; the tufts of cotton are taken from the capsules, thrown into baskets, and conveyed within doors, to be somewhat cleansed from impurities before being shipped to the manufacturers. There are usually two crops in a year, one eight months and one twelve months after the time of sowing; the two gatherings from each plant yield about a pound of cotton fibre on an average; and an acre of plants about 270 lbs.

One of the few machines employed upon cotton before the actual manufacture is the *gin*—an apparatus never seen in action in this country, because we do not receive the cotton in a state which requires its services. When the cotton has been collected from the field, it is found to be mixed up with seeds, the removal of which is essential to the subsequent operations. The earlier machines were very inefficient to this end; but the patent gins now employed do their work well and rapidly. So numerous, bulky, and weighty are the seeds gathered with the fibres from the pod, that they form three-fourths of the entire weight—the weight, as imported into England, being only a quarter of the gross weight. The gins vary considerably in the mode of action; but all contain teeth, spikes, combs, or saw-edges, affixed to a rotating cylinder, and made to shake, and open, and tear the little knobs of cotton so thoroughly as to cause the seeds to separate and fall out.

The laden ships cross the Atlantic, and Liverpool becomes the recipient of these myriads of cotton tufts. If a plant yields 1 lb. of *impure* fibre per year, and if 4 lbs. of this became 1 lb. after being "ginned," and if England's appetite for this commodity extends to 700,000,000 lbs. of ginned cotton in a year—this looks very much as if 2,800,000,000 cotton pods have to be picked by negro fingers (or other fingers) for our annual supply. Although London and Glasgow, and a few other ports, receive portions of these immense cargoes, Liverpool receives the overwhelming majority; and from that busy emporium the bales of cotton are transmitted to the great manufacturing towns of Lancashire and the neighbouring counties—Manchester being the monarch over all the rest.

The cotton factories of the North may be grouped in two great divisions as to locality—the town and the country factories. The former are in the midst of the smoke, dirt, bustle, excitement, competition, and dense population of Manchester, Leigh, Wigan, Bury, Bolton, Blackburn, Preston, Oldham, Ashton, Staleybridge, Hyde, Stockport, and such like towns. Here the huge, black, inelegant, unpicturesque mills present themselves to our view on every side—provokingly free from even an attempt at architectural adornments; their windows are presented in almost endless ranges; their lower rooms are panting with the giant movements of steam-engines; and their chimneys are vomiting forth thick black smoke. Experimentalists have declared again and again that furnaces *can* be made to consume their own smoke, and that fuel is actually saved thereby; and yet the Lancashire manufacturers—shrewd men of the world as any our country can show—are doing very little to carry this smoke-reform into practice; there must be some hitch either in the experiments themselves, or in the logic which deduces conclusions therefrom. But be this as it may, there are the mills, and there is the smoke. And if we take our station near these mills at dinner time, what a sight presents itself! As if by one magic touch, the whole working population of these busy towns seem to make their appearance at once. From every factory gateway troop forth men, women, boys, and girls, all hasting to make the most of the hour which is the allotted space for dinner. Some who have to walk far to their homes set off quickly and alone; some make a lingering, grouping, gossiping affair of it—especially the girls. Some are neat and tidy; some slatternly. The neat and tidy are hastening to homes where a clean hearth and a cheerful hot dinner await them; the slovens belong to homes probably as slovenly as themselves. It is not only by tens, or even by hundreds, that the operatives thus troop out; there are many cotton mills which have upwards of a thousand hands each. Birley's, in Manchester, has nearly two thousand; and when we consider that the mills in Manchester are something like a hundred in number, we may form some conception of the appearance of the by-streets when 'feeding-time' arrives.

Different, far different, are the country mills. The hills which separate Lancashire from Yorkshire give birth to many streams which flow across the former county; and as these streams furnish water power, with river banks which can be purchased or leased cheaply, cotton mills have been gradually established on such spots in considerable number. Out far away from busy towns, the mill-owner has to build cottages for his workpeople; and they thus —master and operatives—form a sort of colony among themselves, or a sort of feudal or patriarchal settlement,—for it partakes something of the character of all three, and is so far entirely different from the town mills, where the mill-owner knows little, and generally cares little, where or how his operatives live. At these country mills, too, water power to a considerable extent is used instead of steam power; and to this extent the smoke nuisance is avoided. Very frequently the mill is seen down low in a pretty valley; on the slope of a hill on one side is the mansion of the mill-owner; while on the other is the workmen's village, the church and the chapels, the school rooms, and the shops of the small traders who supply the wants of the 'mill-hands.' When two or more such mills become built near each other, the operatives tend to coalesce into one larger body, which larger body by and by rises to the dignity of a town's inhabitants.

And if, instead of watching these vast hives of industry on the outside, we glance within, what a scene meets the view! It is a scene in which *intensity*

marks everything. Every minute of time, every yard of space, every practised eye, every dexterous finger, every inventive mind—all are at high-pressure service. There are (in the best modern mills) no lumber attics or lumber cellars; everything is cut out for its work and the work for it. Ascend to the upper range or floor, and what do we see? Probably we are in a room of immense length, lighted by dozens of windows, and into which bales of cotton are being hauled by steam power from below. Machines of large size and fierce action are waiting to receive this cotton, and tear it, turn it, shake it, comb it, and rout it about until it becomes ranged in cleanly and orderly form; while operatives of both sexes and various ages are tending these machines and supplying their insatiable appetite for cotton. Lower and lower if we descend into the building, we find the cotton advancing in its stages towards completion, and more and more hands employed compared with the weight of cotton operated upon. On a level with the floor (if it be both a spinning and a weaving mill, which many are) we find the weaving-shed, with its ranks of noisy power-looms, and its Amazon army of women and girls attending them. Exterior to this, probably, are the boilers and engines which supply motive power to the whole; and beneath are the warming and ventilating arrangements which give the mill-owner a command over the temperature of his establishment.

### Cotton-Mill Operations.

Any one would think, from the wonders achieved by Arkwright and his immediate successors, that cotton-spinning and weaving must have long ago reached their summit of excellence. Yet so far is this from being the case, that every month produces newly-patented machines for one or other of the various processes. The truth is, that although the primary operations are now conducted on a pretty uniform plan, the minor details are subject to constant change and improvement; any increase of fineness in the yarn produced, or of quantity spun in a given time, or of strength in the fabric woven, or of durability in the machine, or of ease in management—any such will warrant the patenting of a new machine. Men do not now search for a new *principle* in cotton machinery; their improvements are in *degree* rather than in kind.

A period of about a hundred and ten years has now elapsed since machinery (in the modern acceptation of that term) was applied to cotton-spinning. Lewis Paul made a carding machine about 1740, for carding or combing cotton more expeditiously than it can be carded by hand. Hargreaves, at a later date, made another and better machine. Paul, too, invented a spinning-frame to act by rollers; and here again Hargreaves improved upon Paul, by inventing the spinning-jenny. It was about the beginning of the reign of George III. that Hargreaves introduced his inventions; he had a desperate battle to fight against prejudices and intrigues of all kinds, and was made poor (or kept poor) by that which was destined to make others rich. Taking the year 1760 as representing what we may call the era of Hargreaves, a rapid succession of novelties appeared. There was Lee's ingenious feeding-apron for the carding machine; there was the 'doffing' apparatus to remove the cotton from the cards or combs; there was Arkwright's spinning-frame, by which stronger yarn was producible than by any earlier machine; there was Crompton's beautiful *mule-jenny*, a sort of compound of Hargreaves' spinning-jenny with Arkwright's spinning-frame; there was Kelly's application of water power to work the mule-jenny; there was the self-acting mule, introduced

by Strutt, improved by many others, and brought to a high degree of excellence by Roberts; there was the 'throstle' improved by Danforth and others; there were the machines for dressing the yarn before weaving, by Radcliffe and others; there were the beautiful card-making machines by Dyer and his successors; there were the steam-power looms, introduced by Dr. Cartwright, and gradually improved by others—all these may be taken as types of classes of improvements, each class containing almost numberless varieties. How many of these inventors were buffeted about and reduced to poverty, and how few became enriched by their ingenuity, the history of the cotton manufacture tells too sadly.

If, in the midst of the din and excitement of the 'machinery in motion' department, a visitor at the Great Exhibition could have steadily followed the travels of a bale of cotton, he would have succeeded in tracing the action of some of the best modern machinery. Let us conjure up the scene again before us, and set the imagination to work.

First, then, here are the bales of cotton, brought from various parts of the tropical world, and weighing 300 to 400 lbs. per bale. The women and girls take out this cotton by handfuls, and feed with it the insatiable *opening machine*. The cotton, laid upon an endless apron, is caught between the teeth of revolving rollers, which effectually tear and separate the locks asunder; the cotton is opened into a light and flocculent mass, and the few remaining seeds and the dirt are expelled. Then the *scutching machine* comes into requisition; again is the cotton placed upon an endless apron, and again exposed to the action of revolving rollers; the impurities are yet further separated, and the beautiful downy cotton becomes lapped in a continuous sheet upon a cylinder. These sheets of down—these softest of all soft layers—were the admiration of thousands who for the first time saw them in 1851. How do we now convert them into delicate yarn? These broad soft sheets go to the *carding machine*, where a number of wire combs, or rather wire brushes, comb the cotton out into straight fibres; and these fibres are dexterously whipped off by a 'doffing' apparatus, to assume the form of delicate narrow ribbons or *slivers*. Next we see all these slivers joined by another machine, so as to form a continuous *lap*; and this lap is again carded and doffed, by which the substance becomes equalized as much as possible. The cotton is thus again brought to the state of a ribbon or sliver; and then are brought into use the machines which convert this ribbon into a yarn or thread. The *drawing*, the *slubbing*, and the *roving* machines all have relation to this conversion; we see numerous pairs of rollers, between which the cotton is drawn; the drawing rounds it, equalizes it, and gives it a slight twist; until at length we see the delicate yarn—fine, perchance, as a spider's web—elaborated from the thick but soft ropes of cotton.

More correctly, however, we should say that the cotton does not become yarn till after the spinning. Nothing excites more astonishment in cotton factories than the *self-acting mule*. The complex carriage, twenty or thirty feet long, with its army of spindles (sometimes as many as 800 in number) travels slowly to and fro, and draws out the delicate threads to a state of still greater delicacy and tenuity; the drawing-out thins the cotton, the rapid revolution twists it; and thus by drawing and spinning do the Houldsworths and the Bazleys of the nineteenth century produce cotton yarn whose fineness almost exceeds belief. And while the *mule machine* is thus making fine yarn for weft threads, the *throstle machine*, by a different mode of action, produces the stronger yarn for warp-threads. Then, again, if it be sewing cotton or hosiery

cotton that is required, we trace the yarn to the *doubling machine*, where two yarns or more are twisted one around another, whereby a much denser thread is produced. The amount of machinery in the spinning-rooms of some of our great mills is something quite astounding; at Messrs. Bazley's, near Bolton (which became a subject of newspaper talk, on account of a visit from Prince Albert in 1851), there are no fewer than 70,000 spindles whirling away at once in one room, each one requiring the co-operation of a number of other delicate little pieces of mechanism.

Another artizan now claims our notice—the weaver; and another group of machines subsidiary to his labours. There is the *winding machine*, by which the yarn is wound on large bobbins. There is the *beaming machine*, by which the yarn is transferred to large beams or rollers. There is the *dressing machine*, by which the yarn is drawn out into parallel lines of warp threads, and stiffened with an application of flour-paste. And lastly, there are the *looms*—hand-looms for the humble weavers in the Lancashire villages; power-looms for the great factories; jacquard-looms for a small number of figured goods in cotton. He who has once been in a room containing a thousand power-looms all working together (and there are many such rooms in our northern counties) will not soon forget it; the drum of his ear is drummed upon most unmusically; he cannot hear himself speak; he can scarcely see or even think; and he must learn to accommodate himself to the clatter around him before he can appreciate the wonders of the power-loom of our day. Steam unwinds the warp from the beam; steam raises the alternate threads to form the 'shed' or opening for the shuttle; steam drives the shuttle from side to side; steam drives up or consolidates each thread of weft as it is thrown; steam winds the calico or cloth on a large roller; and steam rings a bell to tell the attendant how the loom is getting on with its work. The attendant really does none of the weaving; she (for it is mostly a female) watches a couple of looms alternately, to see that the beam has enough warp and the shuttle enough weft, to mend any threads which accidentally break, and to make a number of little minor adjustments; but the giant power of steam—that power which will forge an anchor or make the eye of a needle—moves everything, does everything. In short, so far as regards the bulk of cotton goods produced in England at the present day, steam power is the opener, the scutcher, the carder, the lapper, the drawer, the rover, the spinner, the doubler, the winder, the warper, the dresser, the weaver—he is the master-workman, and the machines are his fingers. The Hindoo can live on something like a penny a day, and has cotton growing close at hand; yet the steam-engine enables us so to underwork in price, and overwork in power, even the patient Hindoo, that we actually exported five million yards of cotton shirting to Calcutta itself, in 1850.

The subdivision of manufactures in Manchester is carried on to an extent which ordinary readers would scarcely suppose. Not only do some establishments confine their operations wholly to spinning, without touching upon those of weaving; but the *fine* yarn and the *coarse* yarn lead to another separation. How to produce most quickly and cheaply the heavy yarns for coarse cotton goods is a very different problem from that of producing most delicately and perfectly the light yarn for fine goods; and those manufacturers who excel in the one do not generally excel in the other. The leviathan establishment of Messrs. Birley, for instance, is a *coarse-spinning* mill; Messrs. Houldsworth's is a *fine-spinning* mill. In the fine mills the material employed is better,

the machinery is worked more slowly and carefully, and the operatives are paid somewhat more highly, than in the coarse mills.

The reader may perhaps ask, in illustration of some of the foregoing details, how much of our imported cotton is woven for home use, and how much for exportation. Messrs. Du Fay, the eminent cotton brokers of Manchester, have afforded the means of answering this question. A portion, as we have said, of the raw cotton imported, is again exported in the same state; the rest, during 1848, 49, and 50, amounted in round numbers to about 600 million pounds annually on an average. It was disposed of as follows:—

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|---|---|
| Waste, during the manufacture . . . | 66 million pounds. |
| Home consumption, thread and woven goods | 163 „ |
| Exported yarn and thread . . . . | 137 „ |
| Exported woven goods . . . . | 234 „ |
| | 600 million pounds. |

The same authorities estimate that, on an average of the same three years, the selling value of the cotton manufactures of the United Kingdom amounted to about £45,000,000; out of which the raw cotton cost £14,000,000—leaving £31,000,000 to be distributed in our own country for wages, &c.

The number of Manchester houses engaged in manufactures quite subsidiary and subordinate to the cotton manufacture is really remarkable. Let us jot down some of these, without much attempt at system, as they occur in alphabetical order in the 'Directory' of that cotton-spinning town. There are bobbin and skewer turners, calenderers and makers-up, card makers, chain and hame (loom) makers, cotton-waste dealers, embossers, engravers to calico printers, fent and patch-work dealers, finishers, fustian shearers, fustian knife and guide makers, heald knitters, iron-liquor manufacturers, jacquard-machine makers, logwood grinders, loom and warping-mill makers, makers-up and packers, pattern card and book makers, pattern designers, picker makers, print-block cutters, reed makers, reelers and makers up, roller and spindle makers, roller leather makers, shuttle makers, size makers, sizers, spindle and fly makers, stiffeners. All these, as well as the larger manufacturers above alluded to, suffer from anything and everything which affect the supply and price of cotton.

### Cotton Novelties, and Cotton Utilities, at the Great Exhibition.

We have already supposed the reader to have learned a manufacturing lesson from the beautiful machinery deposited in the Great Exhibition. But there were many other instructive lessons to be learned there; many cotton novelties, cotton curiosities, cotton utilities. There was raw cotton from Africa, Barbadoes, Cape of Good Hope, China, Egypt, Guiana, India, Malta, New South Wales, Portugal, Russia, Society Islands, Spain, Trinidad, Turkey, United States, and Western Africa. There were the pretty cotton-trees from the United States, with the full pods actually hanging from them. There were cotton seed, cotton waste, cotton yarn, cotton thread, cotton fabrics—all were there, for those to study who were not too much dazzled by the gold and the jewels, the polished steel and the lustrous mirrors.

One among the many contrasts which the Exhibition was so well fitted to illustrate, was that of the *looms* of our own day with those of times long gone

by. Mr. Harrison of Blackburn sent a power-loom of 1850, and another of 1796. The latter, how rude and clumsy—how slow and inexact! And yet it was a wonder in its day. It was one of the very earliest power-looms; it made sixty *picks* or movements of the shuttle in a minute. Although our looms now make upwards of two hundred picks in a minute; although they work better and cleaner; although they do not wear out so rapidly; although one attendant can take charge of two or even three looms—yet is it quite right to regard the rough old loom as a very important memento: a record of the state of things half a century ago, and a standard whence to measure our subsequent progress. As to the power-loom of modern times, it is never the same two years in succession. Little improvements are patented and introduced in rapid succession, so apparently insignificant as wholly to escape the glance of an observer, yet producing great results when systematically worked. It may be the 'weft protector,' or the 'temple,' or the 'positive taking-up motion,' or the 'fast reed and break,' or the 'loose reed and break,' or any other equally unintelligible name; but whatever it be called, every such invention comprises some small piece of apparatus as an appendage to the power-loom, to increase its efficiency. There has recently been a very small and simple improvement in the power-loom, which has realized £20,000 to the inventor for licences to use the patent.

It is really impossible to appreciate rightly the exquisite fineness of our machine-spun cotton yarn at the present day, without some familiar and homely mode of comparison. No. 600, or No. 800, appeals to the spinner's own mind as a beautifully fine yarn; but to every-day folks these designations are meaningless. Let us elucidate them a little.

To produce a finer yarn than has before been produced is one ambition of the cotton spinner. Certain degrees of thickness, called Nos. 20, 30, 40, &c., were the products of the spinning machine in use before the time of Crompton; but when the mule-jenny of that inventive man came successfully into use, the Lancashire spinners were astonished by the production of No. 80—a degree of fineness which had before been deemed almost fabulous. So highly was this yarn estimated, that Crompton obtained *two guineas per lb.* for it. Yet this No. 80 is absolutely a coarse cord compared with the production of the Houldsworths and the Bazleys of 1851. The No. denotes the hanks required to make up a pound, the hank being a conventional designation for 840 yards; therefore if we multiply 840 by the No. of the yarn, we get the length in yards to which one pound of the yarn would extend. One pound of Crompton's wonderful yarn measured 67,200 yards, or about 40 miles. Ten or twelve years ago, the powers of the spinning machines had been so perfected, that yarn No. 350 was produced at one of the Manchester mills—not perhaps for use, but as a curiosity; this was less than one-fourth the bulk of Crompton's yarn—a pound weight would extend 167 miles. A dozen years have thrown even this product far into the shade. Those who remember the arrangement of the cotton yarns in the Great Exhibition will call to mind the specimens of Nos. 200, 300, &c., with specimens also of the laces and the muslins which had been produced from these exquisitely-fine yarns.

But our spinners are determined to show that they can shoot ahead of the weavers altogether; that is, that they can produce yarn which no weaver or weaving machine could work up into a web. This is not a mere braggart display; it is a goal towards which the weaver is invited to direct his attention. When the yarn becomes exquisitely fine, it will not bear the mechanical action of a loom; it would break too readily to go through the necessary

processes. No sooner did the weaver succeed in employing Houldsworth's No. 350, than he and others strove to get again in advance of the weavers; and again the weavers struggled in the race. Such has been the result, that at the Great Exhibition we had sewing thread made from Bazley's yarn No. 600, muslin and net from Houldsworth's No. 600, and French muslin from MM. Vautroyen and Mallet's No. 600. Such muslins as these the world never, perhaps, saw before. We hear of the delicate spinning of the patient Hindoo; we read of the muslin like "woven wind," in which Aurungzebe's daughter was robed; but the sensitive human fingers have been excelled by the iron fingers of the mule machine. To stop at No. 600, however, is what our spinners will by no means consent to do; they have drawn the weavers after them so far; but the yarn has now reached the region of thousands instead of hundreds. Two specimens were deposited in the Crystal Palace, one No. 2070, and one No. 2150; both so fine, that the downy filaments on the surface could be detected only by the microscope; both so minute, that without dark paper being placed behind them, they would be invisible; both so fragile that they would break before they could be wound on bobbins. One pound of yarn No. 700 is said to be worth no less than 28*l.*—so great is the labour bestowed upon it; we have thus so humble a material as cotton raised to a value seven or eight times that of pure silver; as to No. 2150, it must very far exceed in value its weight in gold. In respect to *length*, one pound of this finest yarn would extend more than a thousand miles; three pounds would stretch from Liverpool to New York—a fairy cable connecting the new world with the old—a kind by which Puck might

————————" put a girdle round about the earth
In forty minutes."

Although it is admitted that, from some cause or other, the cotton manufacture was not sufficiently illustrated by specimens at the Great Exhibition, yet there was enough to show how ample is now the variety of such products. The admission of new *names* into the list is one of the oddities of the trade. What these names mean, it would, perhaps, not be very easy to say; sometimes they indicate a degree of fineness in the goods; sometimes the mode of weaving; sometimes a colour, a pattern, a garment for which they are suitable, or a distinguished personage who first wore them; sometimes a foreign product which they imitate; sometimes a country for whose market they are intended, or a town which is the chief seat of their manufacture, or a firm which takes a lead in their production—it matters little what the meaning may be; a new name has a commercial value; and the Shaksperean dictum concerning "a rose by any other name," &c., is not always assented to in shop-keeping philosophy. Let us run hastily over a bundle of these names. We have dress ginghams and fancy ginghams, and umbrella ginghams, checked and striped ginghams, and ginghams known by the high-sounding names of Camperdowns, Coromandels, matallas, vicanas, and briolas. We have book muslins, jaconot muslins, bishop lawn muslins, sacharilla muslins, tarlatan muslins, Scotch lawn muslins, Victoria muslins, India and Swiss mull muslins, leno muslins, striped muslins, lappet muslins, spot muslins, sprig muslins, and a number of other members of the muslin family. We have table-cloths, diapers, huckabacks, jean stripes, clan tartans, galas, Hungarians, and Derries—all made of cotton. There are surongs, crossovers, selampores, Granvilles, denims, panos da costa—all, we believe, of the cotton shawl family. There are counterpanes, quiltings, vestings, dimities, swansdowns,

moleskins, doeskins, lambskins, velveteens, beaverteens, fustians, long-cloths, shirtings, calicoes, everlastings, nankeens, coutils, and other cotton goods, the enumeration of which would be almost wearisome. A few groupings will show the relations between these goods. For instance, the *gingham* family consists of stout cotton, in which threads of two or more colours are woven together into stripes, &c.; *fustians*, *beaverteens*, *velveteens*, *moleskins*, and several others, are woven on the same principle as velvet, with a nap or pile, which is either cut or left uncut; *damasks*, *huckabacks*, *diapers*, *ticks*, and *cambrics*, are cotton imitations of the similarly-named flaxen goods; *quilts* and *counterpanes* have downy tufts to increase the thickness and softness; *shirting* calicos, *sheeting* calicos, *printing* calicos, *long-cloth* and *duck*, are varieties of plain serviceable cotton goods, varying in stoutness; *chintz* is a stout calico, afterwards printed in several colours; *corduroys*, *jeans*, *quiltings*, and many other varieties, are very strong cotton goods, mostly twilled. As for muslins, their variety is almost interminable.

It was a pretty operation to see, at the Great Exhibition, the making of bobbins for cotton spinners; and one which shows how enormous must be the consumption of such articles, to pay for the constructing of machines for producing them. The 'reels' on which sewing cotton is frequently sold, may now be made by such a machine as that which occupied a place in the 'machinery in motion' department. Little cylinders of wood are roughly shaped in another machine; they are dropped into a hopper or funnel; they are seized one by one, and held in a sort of lathe; they are quickly shaped while so held; and they are liberated when complete. All this is done with no other labour on the part of the attendant than feeding the hopper with little blocks of wood.

Of all the machines subsidiary to the cotton manufacture none is more beautiful than the *card-making machine*, an example of which attracted so much attention at the Exhibition. A card, in the language of a cotton factory, is a kind of wire brush, with the wires all bent in a determinate direction; they are fixed into a back or handle of leather; and the card thus made is attached to the rotating cylinders of the carding machine which combs or straightens the cotton fibres. This wonderful little card-making machine punctures the holes in the leather, unwinds the wire from a coil, cuts off about an inch of wire, makes two bends in the wire at right angles to each other, drives the wire into the leather, and clinches it when so driven. The variety of movements necessary to the performance of so many operations is almost inconceivable, and tends to place this machine among the very highest class of mechanical contrivances.

We stated a few pages back, that very few attempts are now made to introduce a new *principle* in cotton manufactures, the course of improvement being chiefly directed to matters of detail. There is, however, a very singular novelty of recent introduction, by Mr. Mercer of Accrington, which seems deserving of note. Mr. Mercer's curious process was described before the British Association at Ipswich, in 1851. A solution of cold but caustic soda has been found by him to act in a remarkable manner on cotton fibres, causing them to contract; and he has also found that, although the soda may be washed out, the effect upon the cotton remains permanent—even to an increase of one-third or one-fourth in the weight of the cotton. The compacting or condensing nature of this effect may be important in manufactures, for a coarse calico or muslin becomes finer in appearance when thus affected. The colours of dyed cotton are also influenced; for the condensation of texture is

accompanied by a deepening and brightening of tints. A third improvement is said to be, that a cotton yarn or a cotton cloth is stronger after having been subjected to the soda process than before. If all these claims to excellence are true—if the cotton goods are made *finer*, *brighter*, and *stronger*, by the soda process—then, indeed, will this discovery prove to be an important one. Dr. Lyon Playfair, in his 'Exhibition Lecture' before the Society of Arts, presented some specimens of cotton goods which had undergone this singular process.

The imparting of *colour* to cotton goods, either by printing or dyeing, is such a large and important subject, and one so chemical in its nature, that we cannot discuss it in the present sheet, devoted as it is to a comparison between flax and cotton. The Exhibition, in this as in other matters, was a great school of instruction. There were the serial specimens exhibited by Messrs. Black of Glasgow, in which small pieces of cotton were displayed in every stage of the bleaching, dyeing and printing processes; and written descriptions, placed beneath the specimens, explained the modes in which the several processes had been conducted, and the chemical substances which had been employed. Little does the lady-wearer of a printed muslin dress imagine how numerous these processes are, and how chemical science has been ransacked to aid the processes. Then, again, there was the 'calico-printing trophy,' really an extraordinary assemblage. It is said that Mr. McCallum, one of the masters of the Manchester School of Design, had almost endless trouble in collecting the specimens; and this may well be believed, considering that old specimens are in all probability few and far between. It was a panorama, illustrative of the progress of this beautiful art. It ranged over no less a period than eighty-six years, comprising specimens of calico-printing from 1765 to 1851. The specimens were fastened end to end into a huge strip, which was then coiled on a cylinder; and a handle transferred this strip from one cylinder to another, by gradually unwinding: exhibiting each specimen at a square opening in front of the apparatus. It was in truth a moving panorama, analogous to those in our public exhibitions.

### Flax: Problem of its Home Production.

Let us now leave the cotton region, and devote the rest of this paper to a glance at the flax-culture, the manufacture of woven goods from flax, and the various schemes now afloat for extending this deparment of industry.

Five sheaves of flax straw were contributed to the Great Exhibition by Mr. McEwan, of Islay—a humble contribution, certainly; but important in respect to the motive which led to it. Shortly afterwards Mr. McEwan, who is a landowner in Islay, published a letter to Lord John Russell, asking for government aid towards the encouragement of the flax culture, in Islay and other highland districts. He stated that, being convinced of the fitness of the climate for this culture, in the Western Islands, he had proposed to two of his tenants to make an experiment; he offered to erect a steeping and scutching mill, to find a market for any flax which his tenants might grow. About 120 acres of flax are growing on his estate in the island, and he states the quality to be of the finest. He asks the Government to assist in employing the destitute Highlanders to grow flax, instead of aiding them to emigrate. His political arguments we touch not upon; but he asserts that there are thousands upon thousands of acres in Scotland, now valueless, which would grow flax of the finest kind; that the climate of the Highlands, from its

humidity, will yield better flax than that of England; that the agricultural money value of an acre of well-cultivated flax is equal to that of wheat, but that its commercial or manufacturing value is greatly larger; that the flax-culture is peculiarly suited to the present state of the Highland population, as it would absorb the unemployed labour both of adults and children; and that the rapid streams of the Highlands would furnish water power for flax factories. He asks the Government to aid the landed proprietors in introducing flax-cultivation as a part of the rotation of crops; to establish a pauper flax-farm in every parish; to establish flax-steeping and scutching mills; and to erect quays in convenient spots for shipping the produce.

Here, then, we are introduced at once into the flax world; we are told of flax in Scotland, and of flax in England; and certain economical arguments are used in favour of flax-culture generally. Every-day-folks know very little of this culture in our own country: it may be well, therefore to say something on this matter.

Flax-cultivation is no new idea in England. In old times it was more thought of than at present—until the recent agitation of the subject. So long ago as 1677, one Andrew Yarranton published a pamphlet under the following magniloquent title—"England's Improvement by Sea and Land; to out-do the Dutch without Fighting; to pay Debts without Moneys; and to set at Work all the Poor of England with the Growth of our own Lands." The burden of this national triumph was—the extended and improved cultivation of flax. During the eighteenth century there was a greater average of flax-culture in England than there has been in the nineteenth. The plain truth seems to be, that the great profits from corn husbandry during the war rendered that a more attractive crop than flax; flax was abandoned, not because it yielded no profit, but because corn yielded more. Now that the artificial stimulus to corn-culture is withdrawn, flax may perhaps have fair play.

Another reason why flax-culture was nearly abandoned in England and the Scottish Lowlands, after having been carried on to some considerable extent, was, that the seed was never saved. Growers are now being told, from all quarters, that they must preserve the seed, which would make a difference of some 6*l.* or 7*l.* per acre. The value of oil-cake (crushed flax seed from which linseed oil has been pressed) as food for cattle is better appreciated than at any former period; it is known that the animals fatten well on it, and that the manure produced by the use of this food is very rich for corn crops. The lowland farmers are now closely calculating this matter—without reference so much to the fibre as to the seed; but if the fibre and seed both find a market, the spinner and the agriculturist may, perchance, both be served by the same crop. Sir Robert Kane, too, tells the farmers that the water in which flax has been steeped constitutes a useful liquid manure.

It certainly is a movement of no slight importance to determine whether we can grow our own flax. The flax, flax seed and oil-cake which we import annually from foreign countries, amount to a value of something like nine millions sterling; and, if the visions of the flax-cotton advocates should be even partially realized, the use of flax must greatly increase. That we should endeavour to grow the flax at home is an advice supported on such grounds as these: that we have large tracts of land well adapted for the culture; that its cultivation and preparation would afford employment to a large number of persons now unemployed; and that the culture would render us less dependent on the exigencies of foreign supply. On the other hand, it is generally (though not universally) admitted, that flax is an exhausting crop for the soil;

and that the whole of the operations, from first to last, would require more skilled labour than is usually found in purely agricultural districts. The balance between these two opposing accounts must determine whether we can compete with the flax-growers of Belgium and Russia. Mr. Warnes, a flax-grower of Norfolk, is enthusiastic in the matter; he says that if one acre out of every hundred cultivated acres in England were devoted to flax, we could employ more than all our redundant and poor population—so numerous are the demands for labour after the flax has been pulled.

It is in this light that the Irish Flax Society ought to be estimated. A little more than ten years ago the Flax Society at Belfast commenced its operations; and, whatever may be the future results, the Society unquestionably deserves thanks for having kept public attention directed towards this branch of culture. One mode adopted was, to send agents—missionaries of industry—among the Irish farmers, to give them every information concerning the method of flax-culture adopted in Flanders. Intelligent persons were also sent from Ireland to Flanders at the Society's expense, to witness the whole range of operations; and the Society also published small tracts or papers, in which plain instructions were given in a plain manner.

From the figures presented by the Society, it appears that flax-culture in Ireland rose in annual amount from 1841 to 1844, fell from thence to 1848, and rose from this latter date to the present time. In 1841, when the Society's operations commenced, there were 250,000 spindles in Ireland engaged in flax-spinning, working up about 16,000 tons of flax annually. In 1851 there were about 500,000 spindles, using 32,000 tons. The number of flax mills in Ireland is now about ninety. Besides the encouragement afforded by the Belfast Society, which limits its operations chiefly to the Ulster counties, much activity has recently been displayed in the south of Ireland, where the cultivation of flax is extending, under the auspices of some of the landed proprietors. A year or so back, when the flax-steeping projects were under discussion, an offer was made to purchase 1000 tons of Irish flax straw, at 4*l.* per ton, to be steeped on the Claussen method; the growers being thus assured of a market, to a certain extent—this being one of the great difficulties to which flax-growers without capital are exposed.

At the annual meeting of the Royal Irish Flax Society in 1851, held at Belfast, striking proofs were adduced of the rapid advance of this culture in Ireland, within the last two or three years. There are now twenty-two counties in connection with the Society. There were about 54,000 acres under flax-culture in 1848, 60,000 in 1849, 91,000 in 1850, and 139,000 in 1851; this last quantity is estimated to be adequate to the production of more than a fourth of the whole flax consumption of the country. But there is this drawback—scutching mills are scarce in Ireland; the poor farmers cannot erect them; and unless capitalists do, the culture will be greatly checked. Of the four provinces of Ireland, Ulster is that which most promotes this culture; in 1851, 1 acre in 44, throughout Ulster, was under flax crop. The average yield of flax fibre in Ireland, for the last three years, is estimated at about 5 cwt. per statute acre; this, for 1851, and at 45*l.* per ton, would give the important sum of a million and a half sterling.

It seems strange that the Flax Society have to mourn over the obstinacy of the Irish farmers, in respect to the waste of the seed. They *will* not save the seed; they insist upon doing as their forefathers have done—retting the stems with the seeds attached, instead of rippling off the seeds before the retting. In every other country the seed is saved, either for sowing or for

making linseed oil; and the estimated value of the *wasted* seed, in Ireland, for 1851, is 300,000*l*. "The Society's instructors," we are told, "have constantly endeavoured to inculcate the importance of this economy; but so deeply rooted is the prejudice against saving the seed, that as yet it is only to a limited extent that farmers have attended to this advice." How provoking is all this—how utterly uncommercial and unthrifty.

The average net profit of flax-culture in Ireland is estimated at about 10*l*. per acre; and as 500,000 acres are required to produce all the flax spun in the United Kingdom, the home-growth of the whole quantity would yield a profit of five millions sterling, supposing (which is, however, a bold supposition) other things to be all favourable. It must be understood, however, that this 10*l*. per acre refers to the flax after it has been steeped, turned, lifted, and scutched; the profit from the actual growth seems to be about 6*l*. per acre.

This question concerning price is evidently one which requires a very searching investigation. The farmers are looking out for cash-accounts, pounds and shillings' estimates, of the results of flax-growing, that they may form a judgment for themselves; and such accounts are occasionally published.

Messrs. Marshall—perhaps the greatest flax-consumers in the world—are doing their part toward the encouragement of flax-culture in England. One of the partners has erected extensive works near Patrington in Yorkshire, for retting and scutching flax; and is offering every inducement to the neighbouring farmers to enter upon this culture. The works are adequate to a crop from 500 acres. The farmers, however, enter upon the 'new-fangled' system rather slowly; and Mr. Marshall has therefore adopted a plan of hiring the land at so much an acre, providing the seed, weeding and pulling the crop—in fact he becomes a flax-farmer himself, and then rets and scutches his own crop. The yield of dressed flax is said to be 5 cwt. per acre, worth 70*s*. per cwt., and 2 qrs. of seed, worth 50*s*. per qr.

It appears, from such accounts as have yet been made public, that profits from flax-culture vary considerably, and that we have yet to learn by future experiment what will be the average proceeds. Sir James Graham has recently advocated very energetically the establishment of the flax-culture in Cumberland.

## Flax: from the Field to the Loom.

Nothing has been yet said explanatory of the mode of culture: a few words must suffice on this point.

The common mode of conducting this culture may be understood from a very brief description. The seed is sown broadcast, in the ratio of about 170 lbs. to an acre; it is then slightly covered with earth, and the earth trodden or rolled down upon the seed. The flax soon appears above the ground; and women and children are then employed in freeing it from the weeds which spring up with it. When the plants have attained a height of twenty or twenty-four inches, and are beginning to present a yellow tinge at the bottom of the stem, they are ready for plucking; they are pulled carefully in small handfulls; they are piled in loose heaps in order to become partially dried; and they are then stored in stacks till further operations are required.

The subsequent processes, too, however much care they may require in practice, are very simple, so far as description is concerned. First, the seeds have to be removed; the plants are drawn through a kind of open comb, which strips off the seed as they pass; or a kind of bat or small flail is employed to beat off the seed; and the seeds, thus separated by 'rippling,' are

used either for sowing a new crop, or for making linseed oil, oil-cake, and other preparations. The cultivator has then to separate the gluten from the fibre of the *hare*, before he can separate the hare from the *boon;* he has to dissolve the gluten, that the fibres may be separable. This dissolving is effected by *steeping*, *retting* or *rotting*. In old times, before the 'flax-cotton' theories were dreamed of, and when men did not work at such a rapid pace as they do now, the growers selected one of two methods—*water retting* and *dew retting*. In the first method, the stems are steeped in water for a week or a fortnight; a fermentation ensues, which dissolves the gluten and loosens the fibres; but if this fermentation be not stopped exactly at the right time, the fibre becomes injured. In the second method, the stems are exposed for three, six, or even nine weeks to the action of dew, rain, and wind on a meadow; the fibre is better, though more slowly, retted than by the water or steeping process. Sometimes a double or medium system is acted on; water-retting for two weeks, and dew-retting for two or three more weeks. When thoroughly dried after the retting, the flax is *broken* and *scutched;* that is, the stalks are so pressed as to crush the woody centre, and are then so beaten as to separate the fragments thus broken. In a simple way the stalks are crushed by wooden levers, which are brought down forcibly upon them, and are then scutched by being beaten in every part; but machines have been invented for furthering both of these processes. When the woody fragments are beaten out, the flax is in a state to be sent to the *flax mill*.

In relation strictly to the beauty of the fibre, Belgium produces finer flax than any other country; but the power of producing large quantities of moderately-good flax at a cheap price is more developed in Russia; hence it is to Russia that we mainly look for a supply. One flax plant may yield a more soft and glossy fibre; another may yield a greater weight; and it is found commercially that the latter is the quality which determines the great bulk of the purchases. The stem of a flax plant may be considered on an average of specimens, to consist of eight-tenths *boon* or solid woody centre, and two-tenths *hare* or fibrous envelope; and this hare contains about half its weight of glutinous soluble matter which binds the fibres together; so that the flax fibre is about one-tenth the weight of the whole flax stem. Now any mode of culture which would increase this ratio would be of more importance than improving the quality of the fibre, except for the finer goods; but the latter is obviously also a notable feature; and thus there are two directions in which the flax-grower may seek improvements in his art.

Let us follow the flax in its ordinary manufacturing career, before noticing the modern suggested improvements.

Flax mills are like cotton mills or silk mills, so far as regards the monotonous, dusky-coloured, wide-spreading, many-windowed frontages; but there is one which eclipses all the rest in boldness and originality of design. This is Messrs. Marshall's flax mill at Leeds. Instead of having several stories, tiers, or floors, one above another, as is usually the case, the whole is here thrown upon one floor—to ensure convenience of supervision, facility of access, uniform temperature, good ventilation, and simplicity of machine arrangements. This monster room is nearly four hundred feet long, by more than two hundred broad; it is five times as large as Westminster Hall; and, until the Crystal Palace was built, this Leeds room was deemed the largest (or nearly so) in the world. The room has a vaulted ceiling, formed of about seventy domes, having skylights at their upper extremities, and being supported by iron pillars. These pillars, as at the Crystal Palace, serve also as water-pipes, to

convey the drainage from the roof. The roof, presenting an area of nearly two acres, was a few years ago covered with mould and grass; so that one could literally take a walk in a green field on the roof of a factory; whether this arrangement is still maintained, we are not aware. The interior of the room is filled with beautiful machinery, for performing all the various operations on flax; and beneath are vaulted passages which contain all the arrangements for supplying steam power, warmth, and ventilation, to the hive of busy operatives working above. It is certainly a triumph of engineering and mechanical skill, when such a building is filled with the finest machines which modern ingenuity can produce. How much mind, how much capital, how much labour, must have been thrown into such an assemblage! How do we here trace the accumulation of many years' experience—the bringing to bear upon one object of so many distinct agencies and sources of power, mental and material, social and commercial!

One of the earliest machine operations is that of separating the seed from the stem; *flax-seeding* machines have been invented, which separate the seeds by the careful action of rollers. Then come the *flax-breaking* machines; these have fluted or grooved rollers, between which the flax stem is made to pass, so that the woody portion becomes thoroughly broken without cutting the fibre. Next come into operation the *flax-scutching* machines, in which revolving arms or blades visit the flax with such vigorous blows that the woody fragments are nearly beaten out, and the fibres to a certain degree separated. After this the *flax-heckling* machines give the flax a thorough combing, by means of long rows of teeth or spikes; the fibres are combed out straight and tolerably clean; and the *tow* or short fibres are removed, to be used for other purposes. The heckled flax is then in a state to be acted on by the various machines which bring it into the state of yarn for weaving; these machines are of three kinds, according as tow, long flax, or cut flax is to be acted upon. The *tow-carding* and the *tow-roving* machines serve for the first kind; the *flax-spreading*, *flax-carding*, and *flax-roving* machines for the second; and the *flax-cutting* machine, followed by those for carding and roving, for the third. The spinning machine follows all these; and it differs from cotton-spinning machines chiefly in having a provision for wetting the flax, either with cold or hot water; there is still a little gum or mucilage among the fibres, and this becomes more manageable in the machine when moistened. All the machines here named are the modern or factory means of operations; in old times all was done on the hand method, and the machines have been very gradually introduced; the old-fashioned scutching and heckling and carding and spinning implements are still to be met with in remote country districts.

Mr. Plummer, the machinist, of Newcastle-upon-Tyne, has patented and brought into use a large number of flax machines. There is a 'flax-breaking machine;' there is a 'double-cylinder twilling machine;' there is a 'double-cylinder heckling machine,' suitable for heckling short flax; there is an 'improved heckling machine,' adapted for long flax; there is a 'rotary disc scutching mill;' and there are 'improved holders for scutching and heckling.' All these machines have relation to the earlier stages in the flax manufacture, and not to those of spinning; but the various processes in the manufacture of flax, as in that of cotton, are constantly receiving aid from the mechanical skill of the engine makers.

It may not, perhaps, be superfluous to remark, that a *flax-mill* does not weave flax into linen or other finished goods; it merely brings the flax into

the state of yarn, to be woven in other establishments. Even the giant flax mill at Leeds is not a weaving mill. At that establishment, under ordinary circumstances of trade, no less than thirty tons (nearly 70,000 lbs.), of flax are said to be worked up weekly into yarn; and it is estimated that, to maintain such a supply weekly throughout the year, would require six thousand acres of flax land to be kept in cultivation. This kind of illustration serves to give an idea of the magnitude of the operations, irrespective of that which is afforded by the number of hands employed. The weaving of the spun flax into various kinds of cloth gives employment to thousands, who work for the greater part in their own humble homes and by the aid of simple hand-looms; but there are also weaving mills, the number of which is gradually increasing, and in which power-looms are employed; here the general features of the factory system prevail.

It is a great thing for Ireland that she has a reputation for linens and damasks; it draws the attention of merchants and dealers towards her, and accustoms the people to those large and comprehensive operations which the factory system is sure to introduce. As early as the beginning of the last century, the manufacture of linen damasks was introduced into Ireland from Germany; and there still exist specimens woven in Ireland a hundred and thirty years ago. The manufacture has gone on increasing in excellence; and it is now considered that the high-class Irish damasks equal any from any other country. Almost all are used in our own country, and the better kinds are so costly that none but the wealthy can purchase them. Hand-loom weaving is invariably adopted for the best damasks; but the power-loom is now beginning to be employed for the cheaper damasks and diapers; and it is hoped that this will create a foreign market for them. The Jacquard-loom is extensively used for the richer damasks, for which its wonderful action especially adapts it. What a Jacquard-loom *is*, a long and wearisome description would scarcely make intelligible; what it *appears like*, the thousands who watched the working of the several Jacquard-looms at the Great Exhibition may perhaps remember; what it *does*, is exemplified by specimens of pattern, or damask, or figure weaving, for which it is specially adapted. In designing table-cloths, table-napkins, and d'oyleys, for royal personages, city companies, club houses, and regimental messes, the damask manufacturers of Ireland sometimes display considerable taste; and this taste afterwards reflects some of its light upon the cheaper and ordinary commercial products. We believe it is yet a disputed point among persons artistically inclined, what kind of ornamentation is best fitted for colourless damasks; human forms and features are seldom damasked satisfactorily, and buildings are very tame affairs when so depicted; at present, heraldic emblems seem to take the lead.

There is another notable fact worthy of being borne in mind, illustrative of the excellence of Irish manufactures in flax. It is understood that Irish cambrics are sent to France in an unbleached state, by tons at a time, to be there bleached and sold as French cambrics. This indicates either that the Irish cambric is better than the French, or (more probably) that for a given quality it is cheaper.

There was no want of flax specimens in our great industrial display of 1851. All countries showed us what they could yield, and in what state they bring the yield to market. Messrs. Lawson exhibited to us specimens of flax, grown in England from British, Dutch, and Riga seed. The foreigners showed us their flaxen fibre as grown in Germany, Spain, Portugal, France, Flanders, Holland, Friesland, Austria, Belgium, Sweden, Norway, Russia, Prussia,

America, Australia, Egypt, Canada, China, New Zealand, and India; and many of the kinds in various stages of preparation. Mr. Donlan afforded the means of comparing flax seed in the natural state with flax seed which has undergone a certain chemical process, said to quicken and improve its growing powers. The Chevalier Claussen displayed, in all the stages from stalk to cloth, the flax to which his remarkable processes are applied, and from which he hopes to be able to produce such valuable materials for textile fabrics. Nor did Mr. Schenck fail to supply us with illustrations of the effect of his hot-water process, as applied to the steeping or retting of flax. The Belfast Flax Society showed how varied is the value of flax, according to the care with which it is prepared for market: Monaghan flax as low as 38*l.* per ton, Antrim flax as high as 100*l.* per ton. And our English counties, too, placed before us specimens of their handiwork, produced under very diverse circumstances: flax and flax seed from Yorkshire; steeped and scutched flax from Hampshire and from Surrey; flax grown and scutched at Farnborough workhouse; flax scutched by the prisoners in Winchester Gaol—all were there.

Nor were the woven flax goods less varied or interesting. There were linen goods from almost every country in Europe; there were damasks and diapers, sheetings and shirtings, and all the well-known fabrics in which flax is the chief or the only material; there were mixed fabrics in which flax was combined with cotton, silk, or wool; there were threads, and yarns, and twists; there were the coarse canvas and sail-cloth, and the fine cambric and lawn; there were the plain goods from the common loom, and the highly-ornate damasks from the Jacquard. There were specimens of flax canvas exhibited whose strength was indicated by the fact that it had been tested to 490 lbs. in the direction of the warp, and to 560 lbs. in the direction of the weft.

In respect to the kinds of goods known by the above names, and other kinds also made of flax, the differences arise from various causes, somewhat analogous to those in cotton goods, but not so great in number or variety. *Linen* is the best kind of quite plain flax fabric; *damask* has a pattern produced by a particular arrangement of the loom; *diaper* and *dornock* are two twilled or tweeled products, having a sort of pattern less intricate than that of damask; *sheeting*, *towelling*, *sail-cloth*, *canvas*, and many other kinds, are coarser and stronger than linen, but, like it, divested of any pattern; *huckaback*, used for towels, is something like diaper, but finer. In all these cases, *colour* has nothing to do with the production of different qualities; the fineness of the yarn, the closeness of the woven texture, and the manner of weaving, being the sources of the various differences which present themselves. Flaxen goods are less subjected to the dyeing and printing processes than those of cotton, silk, or wool.

That flax occupies a lowly position relatively to cotton, is admitted; yet, when we think that 120 million yards of linen and 18 million pounds of linen yarn were exported in 1851, besides other goods, and after supplying the home demand, we cannot but regard it as an important manufacture. Indeed, taking the weight of flax and cotton which we use annually at a thousand million pounds, and the flax ratio to be one-fourth of this, flax may assuredly 'look up' in the commercial sense.

## The Flax-Cotton Projects.

Let us now direct a little of our attention to the *flax-cotton* movement, as it has been called. Mr. Porter, a great authority in the philosophy of trade

and manufactures, is among those who deem this movement an important one. At the Edinburgh meeting of the British Association, in 1850, he said, "The uneasiness which it is natural to feel under the circumstances here described [the deficiency of cotton crops] has led to the diligent and careful inquiry whether some substitute or auxiliary may not be called into action which shall meet the evil that threatens us; and this, it is suggested, may be found in a kindred branch of manufacture—that of *flax*. A very few years ago, when first anxiety began to arise concerning the progress of our cotton manufacture, the resource which has just been named did not present itself. At that time our linen manufacture had not made the progress by which it is at present marked—a progress proportionally equal to any that has been made at any time in the cotton manufacture. . . . . . . . . . An additional inducement to the growth of flax, beyond that offered by other articles, may be found in the fact, that to bring it to the same condition as that in which it is usually imported from foreign countries calls for the employment of a considerable amount of human labour. There is no part of the United Kingdom in which the flax-plant cannot be successfully cultivated; and there is hardly any country whence it might not be brought to supply our deficiencies, should such arise."

One great difficulty which besets this subject is, that the machinery employed for spinning cotton is not well adapted for spinning flax; the former is spun dry, the latter is spun wet; and flax is less manageable generally, less yielding to mechanical agency, than cotton. It is said that the processes of preparing and spinning cotton, of average quality, involve an outlay of about 3*d*. per pound; while the average expenses of the flax processes, on yarn of similar quality, and by the ordinary flax machines, reach as high as 10*d*. If this be so, it becomes indeed important to see whether flax may be so 'cottonized' as to be susceptible of preparation and spinning by the cotton machinery.

One among the many directions in which improvement has been sought is in the treatment of the flax seed itself. The 'pickling' or chemical treatment of seeds is not a new idea; many experimenters have thought, that as the chemical constituents of the soil mainly determine the rapidity or slowness in the growth of plants, so might a little chemical aid to the seed itself be conducive to a favourable result. Mr. Donlan has proposed such a mode of treating flax seed. The particular recipe has not, we believe, been made public; nor does it appear that experiments on a sufficiently extensive scale have yet been made. It would seem as if an enterprising capitalist might render benefit, first to himself and then to the community, by preparing a piece of land, laying it out in patches or sections, steeping or pickling flax seed in as many different ways as there are patches, sowing each section with one particular kind, treating them all alike during growth, and comparing the results when pulled and retted. This would place the various chemical systems in fair competition. Another piece of land might, at the same time, be laid out in sections, all differently manured, and sown with ordinary flax seed, to determine how to produce a good crop with the cheapest manure. This experimental mode of inquiry would certainly yield valuable results, if a man of capital led the way.

But it is in *preparing* flax, after growing, that the purport of recent schemes has been chiefly exhibited. The Chevalier Claussen has certainly displayed much energy in bringing his invention into public notice. He has sent his apparatus to Lancashire, to Ireland, and to other districts, that it might be worked in existing mills, and thereby tested. One experiment was made at

Messrs. Quitzow's mill at Bradford; and, from the ample accounts given in the public journals, we can glean sufficient to present the following sketch.

The first attempt was to prepare long flax fibre for the ordinary linen manufacture. Four hundred weight of flax in the straw was boiled in a stone vat, in water containing caustic alkali; the boiling lasted four hours, which was said to *ret* or separate the fibres as effectually as an ordinary steeping of weeks' duration. It is asserted, also, that the fibre is developed in uniform strength; that it is less discoloured than by the old process; and that much more of the glutinous or gummy matter is removed. The flax was removed from the alkaline liquid, and steeped for two hours in water slightly acidulated with sulphuric acid; this effected the cleansing of the flax, and at the same time rendered the straw a more valuable manure than it would otherwise be. The flax was then in a fit state to be scutched and prepared by the ordinary flax apparatus.

The next experiment was in *cottonising* flax; that is, giving to flax some of the qualities of cotton. The mode of doing this was very remarkable. The separate fibres were cut into short pieces, steeped in a solution of bicarbonate of soda, and then steeped in slightly-acidulated water; the pores became filled with these two liquids; a chemical action ensued between the acid and the alkali, carbonic acid gas was formed within the little tubes, and the tubes were *burst* by this gas. This split fibre has many of the qualities of cotton fibre, and may be dyed and spun nearly like cotton. Chevalier Claussen gives the name of *British Cotton* to this split flax; it is bleached by chemical agency, in the same rapid manner as cotton is now bleached in the great Lancashire works. The bleached flax is then spun into yarn, either by itself or mixed in various proportions with cotton.

*British cotton* being the foundation, we have *flax cotton*, *flax wool*, and *flax silk*—a complete nomenclature, depending on the mixture of cotton, wool, or silk with the prepared flax fibre. The great point aimed at is, that these mixed materials may be carded and spun in the existing machines, without necessitating any revolution in the factory arrangements of the North; and it is also hoped by the inventor, that the woven goods produced from these mixed materials will combine the merits of both components—the warmth of wool, the softness of cotton, the glossiness of silk, the strength of flax. The flax seems, in some varieties of the process, to acquire a sort of felting property, analogous to that of wool. There were, in the Great Exhibition, broad cloths, blankets, and other felted goods, formed of a mixture of wool and flax; but in these instances the felting was probably chiefly confined to the wool fibres. Chevalier Claussen states, in further illustration of the effects of his chemical processes, that if woven flaxen goods be treated somewhat in the same way, they become thickened and receive a richer dye than before. There seems to be much analogy between this and Mr. Mercer's treatment of cotton, noticed in a former page.

There is something exceedingly beautiful about this Claussen process, irrespective of its claims to commercial attention. Microscopic observers, as we have already stated, have long known that there is a notable difference between flax fibre and cotton fibre; the former is a kind of cylindrical tube, while the latter more resembles a flat ribbon; and the tube seems to be much more rigid and less pliant than the ribbon. But by bursting open the tube through chemical agency, and thus laying out the fibre in ribbon fashion, the *inside* as well as the outside of the tube is exposed, and new properties seem to be developed. At one of the meetings of the Royal Agricultural Society some flax was 'cottonised' in

presence of the members; it was steeped in the alkaline liquor selected by Claussen, and in that state appeared like a damp rigid mass; but as soon as it was exposed to the acid, by which carbonic gas was generated and the fibres burst, the whole of the flax spread out into an expansive mass of cottony texture—like leavening dough or expanding sponge. The result is described as having been very striking; for the spectators saw both the beginning and the end of the process during an ordinary sitting. It has been asserted that one pound of ordinary flax, spun to a certain degree of fineness, will produce 21,000 yards of yarn; while one pound of split or 'cottonized' flax will yield 25,000 yards. If this be true, it is indeed a commercial truth of no little importance.

Chevalier Claussen states that he was led by an accident, in the first instance, towards his theory of *cottonising* flax. Walking one day on the banks of a Brazilian river, on his own estate, he saw a white downy substance adhering to some of the trees. He found, on investigation, that a heap of flax straw which he had placed near the river had fermented, that gases had been generated, that these gases had greatly modified the flax fibre, that the fibre had become soft and downy, and that some of it had been washed into the river and caught by overhanging branches. An induction from these facts led the observer to his theory of splitting the fibres.

Another recent scheme is that of Mr. Schenck, of New York. In 1848 he brought before the notice of the Irish Flax Society his plan for flax steeping. It consisted mainly in maintaining the steep-water at a constantly high temperature, by which he considered that he could ret or steep flax as effectually in sixty hours as in two or three weeks on the old method. The Society, after much investigation, recommended the new system—not to the flax-growers, but to persons of capital, who might purchase the flax straw from the farmers, ret and scutch it with the improved apparatus and processes, and sell the flax fibre to the spinners. A few 'retteries' (as these new establishments are conveniently called) are in operation; and the Ulster flax-growers have now a choice between two plans—either to sell the flax straw to the retters, or to ret the flax themselves by the old method, have it scutched at a mill, and sell the fibre.

Two or three processes were patented in 1851 by Mr. Bower, of Leeds, which seem to aim at a medium between the Claussen system and the old system of flax preparation. The chemistry of his plans seems to be intelligible; but its commercial advantages as a system would require a long and careful test. It has been brought under the notice of the Belfast Flax Society.

# CORN AND BREAD: WHAT THEY OWE TO MACHINERY.

A QUARTERN loaf is certainly not among those which we are in the habit of designating machine-made products. We are wont to separate agriculture from manufactures; to consider the former conservative and the latter progressive; to rank the former among the tarry-at-home, and the latter among the go-ahead systems; to think that in the former nature does more than man, but that in the latter man does more than nature; to associate green fields with the one, and smoky factories with the other. All this may, relatively speaking, be true; but it is not true if presented in too marked and decided a form. The records of the Royal Agricultural Society, and equally those of the Great Exhibition, have taught us that mechanical as well as chemical principles are making notable advancements into the domain of agriculture. It may not be that 1852 can "make two ears of corn grow where only one grew" in 1840; but an amount of progress well worthy of attention has been made in economizing (and therefore improving) all the processes of husbandry, and the subsequent processes whereby corn is converted into bread.

The summing-up of the Agricultural Jury of the Great Exhibition is really an important one. It is only about twelve years ago that the Agricultural Society commenced the annual show of (and prizes for) implements. And what has been the result? "Seeing that the owner of a stock-farm is enabled, in the preparation of his land, by using lighter ploughs, to cast off one horse in three, and, by adopting other simple means, to dispense altogether with a great part of his ploughing—that, in the culture of crops by the various drills, horse-labour can be partly reduced, the seed otherwise wanted partly saved, or the use of manures greatly economized; while the horse-hoe replaces the hand-hoe, at one-half the expense—that, at harvest, the American reaping machines can effect thirty men's work; while the Scotch cart replaces the old English waggon with exactly half the number of horses—that, in preparing corn for man's food, the steam threshing-machine saves two-thirds of our former expense; and in preparing food for stock, the turnip cutter, at an outlay of one shilling, adds eight shillings a head, in one winter, to the value of sheep—lastly, that in the indispensable but costly operation of draining, the materials have been reduced from 80*s.* to 15*s.* per acre, to one-fifth, namely, of their former cost—it seems to be proved that the efforts of agricultural machinists have been so far successful *as, in all these main branches of farming labour, taken together, to effect a saving in outgoings of little less than one-half.*" The *italics* are Mr. Pusey's; and well do the words deserve to be made conspicuous.

Let us examine some of the "Curiosities" presented by corn husbandry, the conversion of the corn into flour, and the conversion of the flour into bread and biscuits, so far as they illustrate the great mechanical progress of the last few years. And we may begin with a few general remarks on certain aspects which the subject presents in relation to the Great Exhibition and to other industrial arrangements.

## General Aspect of Corn Husbandry in 1851.

Fine, indeed, was the agricultural display at our recent congress in Hyde Park. It seems to be generally admitted that no department of industry was more efficiently represented. The variety was such as to surprise greatly those who have not known how extensively mechanical aid is now applied to agriculture. For preparing the ground, for sowing the seed, for tending the young plants while growing, for gathering the crop, for preparing it for market—for all these operations machines of the most ingenious kind have been invented. We had barley avelers, carts and waggons, chaff cutters, cultivators, drill grubbers, drill ploughs, drill sowing machines, fanning mills, gorse-cutting machines, grass-cutting machines, grubbers, harrows, ploughs, hay-making machines, hay and straw-cutting machines, liquid-manure machines, mowing and reaping machines, oil-cake mills, ploughs, scarifiers, seed-dibbling machines, agricultural steam-engines, subsoil pulverizers, threshing machines, turnip-cutting machines, winnowing machines—all were at the Crystal Palace. And these were irrespective of the simpler tools for hand-husbandry, such as scythes, chaff-knives, hay-knives, grass-hooks, reaping-hooks, bill-hooks, sickles, spades, shovels, hoes, rakes, flails, and the like.

Nor did foreign countries neglect to show us to what extent similar aid is available among themselves; difficult as it must have been to send many of these ponderous machines across the wide ocean. Austria, for instance, sent us seed harrows, carrot drillers, seed coverers, seed looseners, weed destroyers, subsoil ploughs, and harrows. Belgium exhibited her seed bags, cast-iron rollers, seed mills, ploughs, harrows, winnowing machines, weeding machines, straw-choppers, and grass-clearing machines. Canada contributed grain cradles, many-pronged hay-forks, and ploughs. Egypt showed us her somewhat rude bill-hooks, sickles, hoes, ploughs, and the Norez machine for sowing seed. From France we had ploughs, harrows, winnowing machines, clover-threshing machines, corn-cleansing machines, &c. Holland contributed seed cradles, liquid-manure machines, swing ploughs, turnip-cutters, and a very curious instrument called the *dynamostater*, to measure the strength of the action in ploughs. Switzerland illustrated her hand-husbandry by such simple implements as pitchforks, rakes, scythes, pruning knives, and so forth. Prussia and the various German states sent us chaff-cutters, sowing machines, drills, threshing machines, Flemish ploughs, subsoil ploughs, water-furrow ploughs, and potato mills. The United States—busy in all the fields of industry—exhibited to us some of her Virginia grain-reapers, smut machines, horse-rakes, hay-forks, scythes, ploughs, cultivators, "railroad horse-power seed-planters," grain drills, and—last though not least—the now famous reaping machines by Hussey of Baltimore and M'Cormick of Chicago.

And if we take, among the English agricultural specimens, any one class of implements, what a scene of activity did it not display! Let it be ploughs, for instance. There were nearly fifty exhibitors of ploughs, some of whom sent several varieties. Here we may fairly expect that all which the farmer could do, down to the middle of the nineteenth century, was put forth in the best manner. There were common ploughs, without any distinctive name; there were draining ploughs, "criterion prize ploughs," iron wheel ploughs, wood swing ploughs, broad-share ploughs, double ploughs with wrought-iron beam, "patent N G H ploughs," gold-hanger ploughs, one-way-turnover ploughs, two-horse iron swing ploughs, skim ploughs, welded-joint ploughs, ploughs

with drilling machines attached, double-breast ploughs, double-furrow ploughs, double water-furrow oller ploughs, West Indian ploughs, Netherby ploughs, Tweeddale trench ploughs, shifting-coulter ploughs, friction-wheel ploughs, and others, distinguished one from another by peculiarities which would wholly escape an ordinary observer, but which are significant to the eye of a farmer. There were, too, ploughs of a more ambitious description—such as Lord Willoughby D'Eresby's machine for ploughing land with a stationary steam-engine; Usher's model of a locomotive steam-plough, in which the ploughs, revolving behind the carriage, act as propellers; and Lyon's machine for ploughing, sowing, manuring, and rolling the land in immediate succession.

This agricultural department—this noble glass case 650 feet in length—this area of 20,000 square feet of flooring—shone with a brightness of colours which quite dazzled our foreign visitors. They could not understand the bright red and yellow and blue which here met their gaze. In their own countries, whether on the east or the west of the Atlantic, the implements are seldom or never so bedizened; they have rough work to do, and rough implements to do it; but with us, whether it be for reclaiming bogs and swamps, or preparing the soil for culture, or depositing seed and manure, or tending and cleaning the growing crop, or gathering the crop when ripe, or preparing the crop for market, we find that showy paint is abundantly applied to the machines employed. At the Exhibition this kind of adornment was practised in an additional degree, apparently to befit the holiday occasion. Some of our visitors doubted whether the implements were really good which had received such adventitious aid; and it may, indeed, be worth while for our implement makers to consider whether it comports with the dignity of their excellent productions to continue a practice which was probably first adopted as a lure to the purchasers of common-place goods. Some of the makers have already begun to abandon, or at least to subdue, the brightness of these decorations. Good mechanism, like good wine, is its own best advertisement.

It is a singular feature in modern English agriculture, that debtor-and-creditor accounts of farming enterprises are being made public in a more exact form than used to be the case. Like as an experimental philosopher notes down facts as materials whence he may, by induction, establish principles, so does an experimental farmer note down all the items of outlay, and all the sources of profit, in order to draw out a balance-sheet therefrom. It is true that gentleman-farming involves much fallacy unless scrupulous care be taken to enter all the items on the unfavorable side of the balance; for the real farmer has often difficulties to contend against, which do not affect the experimentalist. Still there is no reason why everything should not be honestly entered to the best of the experimentalist's judgment; and if the results are accepted *approximately*, without being made the basis of too hasty generalisation, good must ultimately accrue therefrom; for men's minds come by degrees to appreciate the relations in which certain items of expenditure and income stand to each other. Mr. Mechi, of Tiptree Hall, in Essex, has become quite a leader among these gentlemen-farmers—these experimentalists who, deriving their capital from other departments of commercial industry, apply a portion of it to investigations concerning farming enterprise. Those who were familiar with the 'Fine Arts Court' at the Great Exhibition, will perhaps call to mind the large model of this Tiptree farm. It showed the economical application of steam power to threshing, grinding, chaff-cutting, corn-dressing, pumping, sack-lifting, and cooking the food for live stock. It also exhibited the new

principle of keeping and feeding animals on open boarded floors, thus dispensing with the use of straw for bedding.

Mr. Mechi has made public more than one tabular statement of the results of his farming experience at Tiptree. One of his statements—his debtor-and-creditor accounts—embraces the period from October 30, 1850, to October 30, 1851. He gives, in the first place, the valuation of his stock at the former date, including the items of horses, sheep, bullocks, cows, calves, pigs, implements, hay, root crops, and manure; the value of all these, under six headings, in pounds, shillings, and pence. He next gives the cost of twelve months' labour, in ordinary farming, trenching, removing rocks and stones, and tending live stock. Then comes a long list of items of expenditure for the twelve months, comprising rent of his own land, rent of land leased by him, a further percentage for his improvements on the leased land, tithes, poor rates, police rates, property tax, surveyor's rate, new implements and tools, repairs to steam-engine, coals for ditto, seed, live stock bought, oil-cake and corn as food for the stock, guano and other manures, interest on the capital sunk in the farm, and miscellaneous expenses. These numerous items are grouped together in twelve entries. Next we have a valuation of the farming stock at the latter of the two dates, showing whether the various items are less or more valuable than on the same day in 1850. Lastly comes a valuation of the twelve months' produce, in wheat, potatoes, mangold-wurzel, turnips, clover, live stock, dead meat, wool, and butter.

The exact nature of the balance between the two opposite sides of this account we do not advert to; farmers have eagerly discussed and closely canvassed the result, and various opinions have been expressed on the matter. But this open and candid discussion is the very thing required; for it must in the end bring out useful results; and it is in such a sense that farming accounts, if honestly prepared, become valuable industrial statistics.

Some of the modern farming enterprises are very instructive, from the scientific mode in which they are conducted. As an example of a high-class establishment of this kind, suited to the steam-engine tendencies of the age we live in, may perhaps be cited Mr. Marshall's farm, near Patrington, in Yorkshire. In our paper on Cotton and Flax, this farm is mentioned in connection with flax-culture; but it appears to be also a farm in the more usual sense of that term. The "Commissioner of the *Times*"—one of those Commissioners whom the energy of our daily press has brought into such a remarkable degree of activity within the last few years—has described this farm, this food-factory, somewhat minutely. Eighteen months were occupied in building and stocking the farm buildings, and in making efficient roads to connect them with the fields. A steam-engine of eight-horse power occupies the centre of the barn; and under the capacious roof of this barn are all the best and newest machines adapted for the in-door processes of husbandry. The threshing machine threshes and dresses the corn, and then delivers it in the granary; it passes thence to the grinding loft, where it is ground and dressed, and whence it descends to a lower story, where it is packed in sacks and laid aside for the baker. From the end of the threshing machine the straw is carried by an endless web to another loft, where it is operated upon by chaff-cutting machines. Other machines break beans and oats for the horses, oil-cake for the cattle, and linseed for mixing with the cut chaff. In the root-house, elevators, worked by the steam-engine, lift the turnips up to a cutting machine, where they are sliced; the slices fall into a truck, and this

truck travels along a railway to the feeding sheds. In another compartment, steam from the boiler boils and cooks food of various kinds for pigs and other live stock. In the cattle houses, each animal has its comfortable box, twelve feet by ten, with a supply of fresh water in one corner, and a manger for its food in another. The railway conveying the trucks of sliced turnips traverses the space between two parallel ranges of cattle boxes. Underground is a great arched tank, into which all the rain-water that falls on the farm-buildings is conveyed by spouts and pipes; from this tank the boiler of the steam-engine feeds itself with water; and the engine likewise pumps up the water to a tank on the highest part of the barn, whence it supplies by pipes all the different divisions of the farm-buildings, and also serves as a reservoir in case of fire. Manure pits, and liquid-manure tanks, are placed so as to render the refuse from the cattle-houses as readily available as possible for use in the fields. The whole establishment, indeed, is an exemplification of the factory system applied to agriculture.

The *Agricultural Colleges* constitute another marked feature in modern times. Let us glance for a moment at that of Cirencester. Here students—boys, youths, and men—are taught various sciences and arts which bear upon agricultural pursuits. Some are boarded and lodged within the college, some in the houses of the masters, some elsewhere. They pay from 40*l.* to 80*l.* each per annum, according to the arrangements respecting board and lodging. Besides regular instruction, and lectures in various sciences and departments of knowledge, the pupils have access to an experimental farm connected with the college, where various theories are practically tested, and instructions illustrated, having relation to grazing, farming, management of stock, preparing of corn for the market, application of steam-power to agricultural machines, and so forth.

There are many other agricultural institutions and farmers' clubs, where the principles of science are sought to be made available to husbandry; they are slowly doing a good work.

We have just mentioned the steam-engines at Tiptree and at Patrington. This marks a notable advance. The application of steam-power to agriculture is one of those measures which are probably destined to exercise great influence on the welfare of this department of industry. There is a general estimate made, that one-fifth of the whole produce of the land is consumed by the horses employed to cultivate it; that is, taking one farm with another, and the average number of horses on each farm, the vegetable produce is diminished 20 per cent. by the time the horses themselves have been fed. This is a serious item. Even if men were to scruple (which few men do at the present day) to employ machinery to supersede human labour, this scruple would have no place in relation to the subject now under notice; it is *horse* labour which agricultural steam-engines are intended to partially supersede. All such operations as threshing corn, cutting chaff, cutting turnips and other roots, crushing grain and seeds, &c., can be very well performed by steam power. Even in districts where coal is 20*s.* per ton, it is calculated that one shilling's worth of coal will do as much work as four shillings applied in feeding a working horse.

One serious matter is, that large farmers only can bear the expense of purchasing steam-engines; the small farmer can barely afford to purchase one, and the operations on his farm are not extensive enough to keep an engine regularly at work. Here, however, a new commercial element comes into exercise. Those who are familiar with Birmingham manufactories know that

steam power is often *let out* in that town; two men, for example, have workshops adjoining each other; one has a steam-engine, but the other not; a belt or shaft is carried from one shop to the other, by which both may have the aid of the steam-engine's power; and the one manufacturer pays a rent to the other for the steam power thus afforded. Now something similar to this is beginning to be applied in the agricultural districts. The owner of a portable steam-engine conveys it from farm to farm, at the seasons when much labour is required, or at such periodical intervals as may suit the arrangements of the farmer; it is used to perform the farm-work, a rent is paid for its use, and it then travels on to another farm—it is a peripatetic operative, which lives upon coals and water, and patiently goes anywhere to do any kind of work for anybody.

The grounds of preference now claimed for moveable instead of fixed steam-engines for farms are something as follows:—in a large farm, with a fixed engine in one spot, there is great waste of labour for man and horse in bringing all the corn to one spot, and making all the operations centre in one spot; if the engine can be taken to the crop, instead of the crop to the engine, power will be economised. If a farm be small, it will not afford work enough for a fixed engine; but a moveable engine might suffice for two or more such farms. The moveable engine enables corn to be threshed with much less expenditure of time and labour than by the fixed engine. In using the latter, the corn is put up into ricks, pulled to pieces again, carted to the threshing barn, and then brought under the action of the fixed engine; but when a moveable engine is employed, the complex threshing machine is attached to it, as a tender is to a locomotive, and both are driven into the corn field (fine weather being of course necessary); the sheaves are tossed at once into the threshing machine, which is set to work by a band or gear from the engine; and it is now found that it takes no more time to thresh the corn in this way than it formerly did to cart the corn to the barn.

### Farm-Machines, as superseding Hand-Implements.

But we must examine a little more in detail the doings of the corn-husbandman, to see in what way, and to what extent, horse labour has superseded hand labour, and the steam-engine superseded both.

Mr. Pusey, in 1850, presented to the Royal Agricultural Society a valuable report on the progress of agriculture during the eight years preceding that date. His discussion of Liebig's celebrated chemical theories we will not touch upon; but the mechanical aids to agriculture come precisely within our range; and it is instructive to see what so competent an observer has to say on this point.

We are told, then, that agricultural mechanism is "certainly the branch in which the increase of knowledge has done the most good to farmers, that increase being partly extension and partly advance." In 1840, in the same parish and with the same soil, one farmer's plough might be seen heavier for three horses than another plough for two. In many places three horses might be seen ploughing light loam: a waste of power never now seen. Agricultural horses are diminishing in number; those entered in the Tax Returns for 1840 were 371,937; whereas those for 1848 were only 297,858. This is a very singular fact, and shows that horse-power is being now more skilfully employed than it was a short time back, owing to the improvement in machines. Mr. Pusey estimates that the actual saving to the English farmers in this item alone,

comparing 1848 with 1840, must amount to nearly a million sterling annually. Another significant improvement is, the substitution of light carts for heavy waggons in field work. Many trials have lately shown that single-horse carts, of the Northumberland build, will bring in a field of corn in about the same time as the two-horse waggon; and that both in the first cost of the vehicles and the horses, and in the daily expenses of the latter, the substitution will have a most momentous effect on the farmer's profits. Our authority speaks of the matter in an unequivocal manner:—"Here (in Wiltshire), since farmers have compared the two systems, no one buys waggons in stocking a farm; but those who have waggons do not like to buy a new set of carts. I should say they had better sell their waggons while they can, and if they cannot, *make a bonfire of them*. To use them still is like running a stage coach in these days between London and Bath."

We may, perhaps, better follow out the object of this paper by tracing the main operations of corn-husbandry in succession, so far as they involve the use of machinery; and see how far Mr. Pusey's paper, and the Agricultural Jury's Report, will aid us. The Report here spoken of is that of Jury No. IX., relating to the agricultural machines in the Great Exhibition; it is printed as a separate pamphlet, and also in the 'Journal of the Royal Agricultural Society.'

And first for *draining*, about which we hear and read so much in the present day.

The draining of arable land has given rise to many machines of great ingenuity. It is not an annual process to be performed by the farmer, nor on some land is it required at all; but in wet soils the landlord now finds it worth his while to bear the expense of thorough draining once for all. Drains or trenches have to be dug, and tiles or pipes laid in these trenches; hence *tile and pipe-making machines* have come to occupy an important position at our Agricultural Shows. Until about 1840 the tiles were made by hand; but now pipes are generally substituted, made by machinery at less than half the cost of hand-made tiles; this diminution of cost has encouraged landlords to drain wet land very largely. So important is the matter now regarded, that at one of the recent shows no fewer than forty-eight of such machines competed for the prize.

The drains or trenches for the pipes are dug by hand with spades; but a bold attempt is now being made to substitute machinery for this as well as other hand processes. Mr. Fowler's *draining plough* is really an extraordinary machine; it ploughs out a channel three or four feet below the surface, and *lays down the pipes* in that channel. The Agricultural Jury recently tried it; and in their report they thus comment on it:—"But for the American reapers, Mr. Fowler's draining plough would have formed the most remarkable feature in the agricultural department of the Exhibition. Wonderful as it is to see the standing wheat shorn levelly low by a pair of horses walking along its edge, it is hardly if at all less wonderful, nor did it excite less interest or surprise among the crowd of spectators when the trial was made, to see two horses at work by the side of a field, on a capstan which, by an invisible wire-rope, draws towards itself a low framework, leaving but the trace of a narrow slit on the surface. If you pass, however, to the other side of the field, which the framework has quitted, you perceive that it has been dragging after it a string of pipes, which, still following the plough's snout, that burrows all the while four feet below ground, twists itself like a gigantic red worm into the earth; so that in a few minutes, when the framework has reached the capstan,

the string is withdrawn from the necklace, and you are assured that the drain has thus been invisibly formed beneath your feet."

This thorough draining is a heavily-expensive operation. But let us next watch the more general and annually-recurrent operation, of which that of the *plough* is an important one.

The minute shades of difference in the arrangement and action of ploughs are quite beyond the appreciation of ordinary observers. The last quarter of a century has produced modifications and improvements almost out of number. Some of the new patent ploughs owe their distinctive character to being made of wrought iron; others are specially adapted to penetrate the ground to particular depths; one manufacturer prides himself on the geometrical accuracy with which the curves of the share and the furrow-turner and the mould-board are planned; another seeks to attain a certain symmetry and compactness in the arrangement of the several parts; another is noted for the mechanism by which the share is fixed higher or lower according to the state of the soil; here we have a peculiar adjusting power for the coulter; there a novelty in the application of the draught or pulling force of the horse; in one, by a change in the mould-board, the same plough may be used for heavy and light land; in another, the parts are susceptible of being readily taken to pieces, for the convenience of emigrants. Nor are foreign countries wanting in modern novelties in ploughs; though we may fairly claim to be ahead of most of them in this matter. The Belgian ploughs are still strong and stout, but rough and heavy; the Austrian, the French, the North German, the Dutch—all are somewhat rude. But our brethren across the Atlantic show a good deal of neatness and cleverness in their ploughs; the woodwork of these ploughs (white oak, of great toughness) is made by machinery; and it is thus so accurately fitted, that all the parts can readily be taken asunder for repair or for removal to a distance.

The Jury Report informs us that it was Messrs. Ransome who furnished the modern English plough with two low wheels, and with mould-boards adapted to different soils. Mr. Howard and Mr. Busby have especially directed their attention to the mould-boards—those curved surfaces which, after raising each furrow-slice of ploughed earth, gradually lays it over half inclined on the preceding slice. Foreigners are said to have been struck with the length of the English mould-boards, at the Great Exhibition; this length has been found advantageous for the stiff clay soils of England.

In respect to harrows, the square-bar harrow, with straight-set teeth, has been used from the earliest times till within the last few years. Harrows are now made with the teeth diagonally arranged, so that the frame which contains them can be drawn square forward instead of obliquely. There is also a very ingenious *expanding* harrow now in use, in which the cross bars are jointed loosely, so that the tines or teeth can increase or decrease their mutual distance behind and before, by decreasing or increasing the distance to the right and left—like the 'lazy-tongs.'

Another implement which assists in preparing the soil is the *roller*. This, like the plough, has undergone great improvement recently. "Not many years ago," the Jury Report tells us, "the landlord was often asked by his tenant for some old tree to convert into a roller. The tree roller, when manufactured, had its framework loaded with rough materials to give it weight; but it soon wore and cracked." Sometimes there was no framework at all; but the traces for the horses were fastened to two pins at the ends of the roller. Now, however, our Crosskills and others have produced excellent rollers, some serrated and

some plain. Farmers used to break their stiff clods partly by the harrow and partly by the plain roller; but now the *clod-crusher*—a kind of roller bristling over with teeth—effectually breaks down the hard lumps of earth which impede arable culture. The Norwegian harrow, a kind of triple roller armed with much sharper teeth than the clod-crusher, is another modern implement for breaking the clods.

The implement called by the various names of *grubber*, *scarifier*, and *cultivator* is a kind of substitute for the plough; it is a modern invention to which great value is attached by experienced men. The Jury Report encourages an expectation that the cultivator may, when brought into general use, save one-half of the entire labour now bestowed upon ploughing; and that it ought to take rank with the reaping-machine, in its prospective value to practical farmers. The scarifier or cultivator cuts up five feet width of soil at once, but to a less depth than the plough; and this wholesale cutting up, when adopted at a certain season, saves three or four ploughings; the instrument has generally about eight or ten tines or cutters, something like ploughshares.

Next we come to the *drills* or *seed-sowing machines*. These are not less marked by diversity than the ploughs of the present day. Let any one examine the drills in the Great Exhibition, or in the Smithfield Cattle Shows, or in the annual shows of the Agricultural Society, or in the trade-circulars of the various manufacturers—he will see ample proof of this. Some of the drills are for sowing turnip seed only; some are equally adapted for all seeds; some deposit manure in the same holes as the seed; others lay the manure at a trifling distance from the seed; one manufacturer attends particularly to the driving or steering apparatus, by which the drill is made to do its work in regular straight lines; another tries to make his drills work well on the side of a hill; in one drill we see the seed descend through a string of tin cups, each dipping into the one below it; in another a vulcanized india-rubber tube supersedes the cups; some are two-row drills, while others are four, six, eight, or ten; some of the manure-drills are so nicely adjusted that they can be made to drop small portions of pulverized manure at any required distances apart.

"The sower with his seed-lip," says the Jury Report, "has almost vanished from southern England, driven out by a complicated machine, the *drill*, depositing the seed in rows, and drawn by several horses." Although horses are used for the drill, and not in hand-sowing, yet horses are used for the harrows which follow the hand-sower, and this to such an extent that it is calculated one-half the horse-power is saved by adopting the drill instead of the "broadcast" method of sowing. There is a saving of seed, too, by the drill. But the Jury Report, which discusses this subject with much clearness, states that the proper mode to view the drill is as the keystone of what may be termed machine-agriculture; the scarifier loses much of its value unless the drill, instead of the broadcast method, follows it; and the horse-hoe—another important member of the machine series—requires the drill to precede it. The drills are costly machines, some rising to the price of £40 or £50; but the makers are cheapening them, and are introducing many varieties among them. The jury instituted a trial of twenty drills at Pusey—ten-rowed corn drills, ten-rowed corn and seed drills, three-rowed drop drills, two-rowed turnip drills, hill-side drills, general-purpose drills, self-adjusting steerage drills—all were there, and others besides. There was also a hand-barrow drill, worked by a man instead of horses, which obtained a highly-eulogistic character. The modern drills not only economize seed, but manure also. Farmers used, not

long ago, to scatter the lime or phosphate or other manure over the whole surface of a field; but now the manure-drills concentrate it in lines along the rows of seed; nay, Mr. Hornsby's drill drops the seed and manure, by a second advance in mechanic frugality, only at those points in the lines where the plants are intended to stand. This has been well characterised as "an elastic pliability by which mechanism in agriculture has seconded chemistry."

There has been a very striking improvement in drills made recently, by which a wholly new principle is brought into requisition—wholly new, at least, so far as regards the art of sowing. We cannot do better than give Mr. Pusey's account of this matter:—"The most striking novelty is Chandler's water-drill, which bids fair to remedy a great evil for southern farmers. Often when our land in July is ready for the turnip seed, on the success of which depends our flocks' subsistence in winter, that land is as dry and dusty as a turnpike road. We watch vainly every cloud, and in vain set our weather-glass; weeks pass without rain, or, worse still, a shower falls, but we find that the rain has not entered the ground. This drill, however, deposits along the line of seed enough water, which serves also as a vehicle for manure, such as superphosphate, to start the young plant in readiness for the coming change in the weather. It is used extensively by practical farmers in Wiltshire, and bids fair to remove from the root-crop one of the farmer's peculiar obstacles—uncertainty, to remove which, if there be a leading object of improvement in agriculture, is the main object."

Mr. Pusey, both in the Agricultural Journal and in the Jury Report, does his best to recommend the *horse-hoe* and the *horse-rake* to the notice of farmers, as being valuable applications of horse-power to field labour. The horse-hoe has a row of hoes or knives, at a distance apart equal to that of the rows made by the drill; whether the seed be turnip or wheat, this compound hoe will drive fearlessly between the rows, and hoe them effectually. So nicely do the parallel hoes do their work, that "for a field operation," Mr. Pusey remarks, "it is as delicate as the action of the revolving knives with which the loose threads are shorn from the surface of broadcloth at Leeds." He gives the farmers some hard rubs concerning their waste of horse-power in field waggons, and states that the expense of a horse-hoe would not equal the *difference* between that of a two-horse waggon and that of an equally efficient single-horse cart.

### Machine Processes, from the Harvest to the Granary.

As we are here treating of agricultural matters only so far as they have been brought within the range of machinery, no apology is necessary for our skipping over the more minute, patient, and manipulative processes which engage so much the attention of the farmer. We will suppose the field of corn to be ripe, and then see what the machinist has done for this corn.

Of all the recent applications of machinery to farming, none have excited greater attention and astonishment than *reaping machines*. Threshing machines have ceased to be a novelty; but reaping machines are only now taking fast hold of the position which they are destined to maintain. How the reaping-hook and the sickle are employed by hand labourers, every one knows who has walked through a corn-field in harvest time; the stooping position and the slow progress have often suggested to the observer that a day *must* come when some plan more efficient would be adopted.

At the beginning of the present century, Parliament voted a reward to the

inventor of a reaping machine; but the machine was so intricate that it gradually fell into disuse. Another was afterwards invented in one of our colonies, but it cut off only the heads of the corn, leaving the greater part of the straw standing—a serious impediment to proper culture. One or two other machines were afterwards invented, but they went so completely out of use that, at the opening of the Great Exhibition, the two American machines appeared almost like perfect novelties.

Mr. McCormick has given an account illustrative of the slow steps by which his machine arrived at efficiency. His father, a farmer in Virginia, made two different attempts, at periods long apart, to construct a reaping machine; he abandoned both as being unsatisfactory. In 1831 the son began his experiments, and in that year constructed a machine for reaping. It is one of the peculiarities of a reaping machine, that it can only be tested during a few weeks in the year; a manufacturing machine, in most other trades, can be used or tried at all seasons of the year; but a reaping machine only comes into use when the corn is ready for harvest. Hence it happened, that when any defect was found in Mr. McCormick's machine, he had to wait nearly twelve months before he could test the usefulness of any changes or improvements he might make. It was nine years before he sold a single machine, and fourteen years before a regular demand arose. At length, the year 1845 saw the machine completed; and since that time there has been a sale in America for about a thousand annually. It seems strange that six years should elapse before these machines became known in England, and that our Great Exhibition should be the means of making them known; but England has always looked rather for raw produce than for machinery from the United States; and, moreover, agricultural machines are ponderous articles to transmit so great a distance.

A few words must suffice to explain the principle of action in this machine. Two systems have been tried in the machines hitherto made: the one to cut by a series of clippers or shears, and the other by a revolving plate. In McCormick's machine there is a cutting blade about an inch in breadth, jagged or toothed in the front edge; it extends across the front of the machine near the ground, and has a reciprocating or oscillatory horizontal motion given to it. Over this blade is a light reel, to which are fixed oblique blades or spars of deal; these spars, when the reel revolves, get behind the stalks of standing corn, and hold them steadily while being cut; the stalks are pressed between projecting tines or fingers, and are there cut by the saw-like action of the blade. When the stalks are thus cut near the ground, they fall on the floor of the machine. The reel, with its windmill-looking appendages, is the strangest part of this machine; it seems at first as if it would beat out all the ears from the corn as it revolves; but this we may presume has been guarded against by the inventor.

There has been, and still is, a battle raging between two reaping machines, McCormick's and Hussey's, both from the United States. It is quite plain that both are very efficient machines; and that though, rather from untoward accident than design, one obtained a "council medal" and the other did not, the jury would have been very glad if both had obtained this much-coveted honour.

On one of the trials made before the Exhibition Jury, McCormick's machine cut fifteen acres in ten hours, and did it lower down the stalk than by ordinary hand reaping. Mr. Pusey's estimate of the saving by the use of this machine is extraordinary; he assumes 9*s.* an acre to be the labour-wages for ordinary

reaping, making 6*l.* 15*s.* for fifteen acres; he estimates the wages for the two men on the machine, the sheaf binders, and the horse food, at 2*l.* 7*s.* 6*d.*, leaving a margin of 4*l.* 7*s.* 6*d.* in favour of the machine; in strictness, a small percentage ought to be added to this, as interest on the cost price of the machine and the two horses. But Mr. Pusey thinks that a feature of greater importance than this saving is, that the machine may enable the farmer to save more of his crop in bad seasons and late districts by its rapid rate of action.

On one occasion Mr. Hussey's machine was tried before a large concourse of persons at Hadham Hall, near Bishop's Stortford. It first cut a field of barley, then a field of clover, then a field of wheat, and did its work so cleanly and quickly as to astonish all the lookers-on. One incident (if newspaper reporters told it correctly) must have been very rich in its way. A Herculean smockfrocked spectator, with a reaping-hook in his hand, was so overwhelmed with astonishment at what he saw, that he broke his reaping hook and threw away the pieces, in despair of ever equalling this magical corn-cutter. In another trial at Windsor, before Prince Albert, Hussey's machine was tried upon a very rough and uneven piece of ferny ground; the machine cut the ferns very rapidly, cleanly, and close to the ground; and Mr. Hussey himself, standing on the platform as the machine moved along, raked the fern off the platform on the ground in heaps of convenient size for gathering into sheaves. The arrangement of the cutting points or edges seems to ensure a kind of clipping of the stalks, analogous to that by shears, whereas McCormick's has a cutting action more like that of a saw. In a trial of the two machines at Tiptree, the verdict was given in favour of McCormick's; at another trial near Middlesborough, the verdict was most decidedly in favour of Hussey's. "When doctors disagree," &c.; we may, however, safely settle down into the conclusion that both are admirable and important contrivances, and that probably each one is better fitted for a particular crop or a particular state of the ground.

These two are not the only reaping machines now attracting public notice. Some short time ago, the Hon. Mr. Tollemache, travelling in the United States, saw one of the reaping machines in operation (we do not know whether Hussey's or McCormick's), and was struck with its effective action; on his return to England he described the machine to Messrs. Garrett; and those eminent implement makers—partly from his description and partly from their own ingenuity—produced a new reaping machine, which was brought before public notice in the early part of 1851. This machine cuts wheat, barley, oats, or beans; it acts nearly on the same principle as the other two machines, and cuts about an acre in an hour. There is a machine recently invented by Mr. Winder, for cutting corn or grass by a series of rotating horizontal knives, adjusted in a singular manner. There are many other reaping machines of recent invention now trying to make their way into the market and into the corn field; but it must be confessed that—like American revolvers and American pick-locks—American reaping machines are at present in the ascendant.

It was one of the notable stages in the history of English agriculture when the *threshing machine* invaded the domain which had before been held undisputed by the *flail*. All our manufactures experience analogous changes. A time comes when inventive talent, spurred on by the obvious imperfections of the old hand implements, contrives a machine which saves a great amount of labour, and very likely performs the work more efficiently. This machine is introduced; it is tried by the inventor or others; a great outcry is raised by those

whose labour is displaced, and by others who advocate their interests; entreaties and complaints, threatenings and violence, succeed each other; the machine gradually conquers its opponents, and matters gradually adjust themselves to a new order of things. Such has been the case in respect to the instruments for separating grains of corn from the straw; every year is the threshing machine seen to be more and more employed, and every year are the old-fashioned flails lessening in number. In the earlier machines the grains were liable to be rather more broken or bruised than by a well-managed flail; but the implement makers have gradually surmounted all obstacles.

Threshing machines bear a pretty general resemblance to each other in their mode of action. The essential part is a large cylindrical drum, on the outer surface of which are fixed bars or beaters parallel with the axis; the drum is made to revolve with a velocity of five hundred to a thousand turns in a minute. The stalk of corn being passed between feeding rollers, it comes in contact with the beaters on the rapidly revolving drum; the grain is beaten out and falls to the ground, while the straw passes on to the other side of the machine. Most of the threshing machines have straw-shakers attached, to separate more effectually the straw from the grains of corn. Among our most noted manufacturers, the threshing machines are usually made from five to nine horse-power; most of the machines (down to the present time) are worked by horses, who go round in their monotonous circular course two or three times in a minute; in an average machine, about a hundred sheaves of corn can be threshed in three minutes. The revolving drum being the common type of all the machines, minor improvements are introduced by particular makers; one has applied anti-friction wheels to the axle of the drum; another uses serrated instead of plain beaters; some of the machines are fed with the corn-stalks in a vertical position, some horizontal; in one kind the maker cares only for the complete extrication of the corn from the straw; while in another, which is to be worked near towns, where clean unbroken straw has a good and ready sale, the mechanism is so constructed as to leave the straw in as whole and unbroken a state as possible.

The Jury Report, in reference to the efficient threshing machines of modern days, adduces a very extraordinary fact, which this Exhibition Jury has undoubtedly done much to bring to light, viz., the enormous loss of power in the ordinary horse machines. The threshing machines which superseded the flail are worked by three or four horses moving in a circle; but it has been found that, until very lately, the various wheels, shafts, levers, and other working parts were so unskilfully adjusted that *three horses out of four* are employed in moving the dead weight of the apparatus itself, and only one horse-power left for the actual threshing. Mr. Amos, the consulting engineer to the Royal Agricultural Society, discovered this fact only three years ago; and the implement makers, made acquainted with this rather glaring proof of forgetfulness, are now busied in devising a better arrangement of the working parts. But when the threshing machine is worked by steam instead of horses, the saving of power is very notable. The Jury Report gives the result of some investigations by Mr. Pusey, to ascertain the relative cost of different modes of threshing: he puts down 3*s.* 5*d.* per quarter of corn for the flail method, 2*s.* for the horse threshing machine, and only 9*d.* for the steam threshing machine; wages, horse-food, coals, use of the engine, wear and tear, all seem to have been charged. This result, if correct, is certainly very important. A still later experiment has shown the steam method to be

capable of threshing and *winnowing* at an expense varying from 6*d.* to 8*d.* per quarter.

The *winnowing* machine, like most other machines in agriculture, has now become an important economizer of time and labour. Instead of trusting the threshed corn to the action of the wind, to separate the grain from the husk or chaff, it is placed in a machine which works with great rapidity and exactness. Hornsby's winnower or dressing machine not only separates the good from the bad in this way, but actually discriminates and separates six qualities, known technically by the names of *best corn, good tail, tail, whites, screenings*, and *chaff*. It effects this separation at the rate of fifteen quarters in an hour; and dresses the whole of it a second time at the rate of twenty quarters in the hour; so that a wheat-rick of twenty quarters can be made ready for the market in five hours.

### Corn, In its Commercial and Marketable Relations.

Before tracing our crop of corn to the miller and the baker, let us note a few facts illustrative of the vast influence which such crops exert on the ordinary commerce of the country. We are a bread-eating nation; but we seldom pause to consider how the supply is kept up, nor how admirably the ordinary routine of commerce suffices to ensure a supply wherever the pence are forthcoming to pay for it.

Nothing shows better the magnitude of our operations in respect to bread and its materials, than the course of commerce in one of our great ports during a definite period. Take, for example, the corn-trade of Liverpool during the year 1851, as given in the trade circulars of that wonderful town. Corn is now the greatest of all imports at Liverpool, with the single exception of cotton. Ireland used to be the granary for South Lancashire; but Irish agriculture has been shaken in various ways; and supplies now pour into Liverpool from foreign countries in enormous quantities—to be either consumed in the manufacturing districts, or to be re-shipped to other ports. At the beginning of the year 1851 there were in stock, in the Liverpool warehouses, 300,000 quarters of wheat, 300,000 barrels and 100,000 sacks of flour, 50,000 loads of oatmeal, and 100,000 quarters of Indian corn. There were imported into Liverpool, during the year, 750,000 quarters of wheat, 430,000 sacks and 1,500,000 barrels of wheat flour, 200,000 quarters of oats, 300,000 loads of oatmeal, 70,000 quarters of barley, 330,000 quarters of Indian corn, and small quantities of other kinds of grain and meal. Notwithstanding these almost incredible importations; notwithstanding that these, added to the stock at the beginning of the year, make an aggregate of 1,750,000 quarters of grain, and 1,800,000 barrels, 530,000 sacks, and 350,000 loads of flour and meal; yet the stock in hand on January 1, 1852, was very much smaller than on that day twelve months; so enormous has been the sale at Liverpool. It was not until ten years ago that Indian corn was imported to any notable extent into Liverpool; yet we find that the merchants of that port disposed of 400,000 quarters in 1851. Almost all the Indian corn imported into Liverpool is re-shipped to Ireland; a portion of the wheat is re-shipped to other ports; but by far the greater part travels inland, and spreads itself over the country.

London, as may be supposed, receives within its vast and busy port much more corn than is required for its two millions of indwellers; it is a centre

from which corn distributes itself to other great markets. The supply of corn received in London during the year is of course immense. In 1849 it amounted (in round numbers) to 1,050,000 quarters of wheat, 650,000 of barley, 1,300,000 of oats, smaller quantities of a few other kinds of grain, and 230,000 sacks and 45,000 barrels of flour; the proportion received from abroad is many times greater than that received from our own home counties. In 1850 the quantities of every kind brought to London were smaller than in 1849—thereby indicating an altered state of the markets, British and foreign.

Taking the whole country, and estimating the flour and meal, as well as the corn, by *quarters* instead of *sacks* and *barrels*, we find that the United Kingdom imported from the colonies and from foreign countries the following quantities in 1850:—4,800,000 quarters of wheat and wheat flour, 1,040,000 quarters of barley and barley-meal, and 1,160,000 quarters of oats and oatmeal—giving the immense quantity (added to our own home growth) of 56,000,000 bushels of these three kinds of corn, besides Indian corn and a few other kinds. France sent us more in that year than any other country, Prussia next, Russia third, and the United States fourth. Those who wish to compare these various entries must bear in mind that 380 lbs. of flour is about equivalent (in bread-making power) to one quarter of wheat. The quantity of wheat flour imported from France alone in 1850 was something quite enormous—placing at a wide distance anything that had before occurred; it was very nearly 2,000,000 cwts.! In 1851 our imports of grain amounted, in round numbers, to 6,000,000 quarters, besides flour and meal.

It would be well if we had in England any such agricultural statistics as those which the Earl of Clarendon has caused to be obtained in Ireland. The constabulary force has been occasionally employed in that country, within the last few years, in making most minute investigations into the state of Irish farming. We are not cognizant of any trustworthy estimate of the quantity of corn grown annually in Great Britain.

The warehousing of corn—that intermediate commercial stage between farming and grinding—is an important matter, requiring capital to support it and care to conduct it. Partly from the operation of revenue laws, and partly to meet the exigencies of various markets, corn has frequently to be kept for a long period in the granary; and great caution is then necessary to prevent it from becoming damp or otherwise injured. So far as the metropolis is concerned, the commercial history of a quarter of corn is somewhat as follows:—The farmers and great dealers in corn send up to Mark Lane, three times a week, samples of the corn which they have to sell; these samples are consigned to corn-factors or corn-brokers, who lease or rent stands at the Corn Exchange. The millers, mealmen, corn-chandlers, and others who wish to buy corn, attend at the Corn Exchange and make their purchases; they judge only from the samples, and deal only with the factors—knowing nothing and caring nothing who may be the actual sellers. The broker or factor obtains the best price he can for his client, and receives a small commission for his trouble. In short, it is so far analogous to most of the great trading operations in the city, where a broker takes a world of trouble off the shoulders of the seller, and often obtains a better price for him than he could himself.

Whether corn is collected from various home counties, and centred at a great emporium like Wakefield; or whether it comes from abroad, and is stored on the banks of the Thames, or the Mersey, or the Humber—it is placed in large lofty granaries. It is spread out in layers on extensive floors,

which layers are gradually increased in depth or thickness; and by being shovelled about and turned over from time to time, the corn is preserved in good condition—sometimes for several years. Some of the granaries at Dantzic are nine stories in height. In some countries the corn, after being dried and aired, is kept covered up in pits.

As we have already briefly adverted to the fine display of agricultural implements in the Great Exhibition, so might we now, if it were deemed necessary, show that corn-crops and their products were to the full as amply illustrated. In respect to corn itself, there were thirty or forty exhibitors, headed by Prince Albert; some sent wheat, others oats, others rye, others barley, and various kinds of grain. Some of the specimens were intended to show how a particular soil is suited for grain; some were illustrative rather of the effects due to particular manures; while others again were associated with particular systems of rotation in arable culture.

But in this we were far outdone by our foreign friends. Those countries (and they are many) which depend rather on agricultural than on manufacturing industry, naturally sent to our great international display the best that they could produce in the shape of corn. No less than thirty different foreign countries and colonies sent us corn specimens; and of these, Russia, Spain, Canada, and Belgium, were particularly rich in the number of exhibitors. Those who remember the Russian section will call to mind the excellent mode of arrangement adopted to display the agricultural specimens. It is true that very few persons are competent, on handling a few grains of corn, to predicate anything concerning the excellence of the soil or the skilfulness of the culture; but it was a point of much importance that those who are competent should have such an opportunity as was afforded at the Crystal Palace.

And the instruments for harvesting or preparing corn, and for bringing it into the edible form of flour, and bread, and biscuit—these were neither few nor unimportant. Some of them have already been named in a former page; but others are fully as much worthy of attention. There were corn-drying machines; corn and grain cleaning and dressing machines; corn and grain grinding and crushing mills; corn and seed meters; corn-stack levels; corn-whisps and dusters; millstones for flour mills; and various other machines and implements having relation to corn before it assumes the form of flour. Then, besides corn-flour exhibited by about sixty persons, English and foreign, we had flour-dressing machines, flour extractors, winnowing machines, and others, which relate to flour rather than to unground corn. Next, carrying forward the industrial history of a corn-crop to a further stage, we had bread-making machines, bread-cutting machines, biscuits, biscuit-baking machines, and ovens of various kinds.

But we must hasten to see what the miller does with the corn which reaches his mill, and whether modern machinery has given a new aspect to his operation.

## Corn Grinding, from the Hand Mill to the Steam Mill.

In almost all the modes of grinding corn—by the hand mill, the cattle mill, the water mill, the windmill, the steam mill—there are two horizontal stones one above another, between which the corn is ground by the rotation of the upper stone. The hand, the cattle, the water, the wind, the steam—are the

agents for rotating the upper stone; it is to the two stones themselves that the actual grinding process is due. The upper stone has a hole in its centre, through which the corn falls; and the distance between the stones, which is susceptible of adjustment, determines the fineness to which the corn can be ground. The opposing surfaces of these stones are furrowed with channels which extend from the centre obliquely towards the circumference; and being in opposite directions, these furrows meet each other like the blades of a pair of scissors. These channels serve to convey the ground flour to the edges of the stones, where it escapes into a box or receptacle. The number and direction of the furrows seem to be left to the fancy of the miller, without any very definite rule.

There are some very peculiar features connected with the manufacture of these grooved millstones. It is not every country that can boast of possessing the proper stone; indeed very few can, and among these few, France and Germany take the lead. At about ten miles from Coblentz on the Rhine, and near the small town of Andernach, are the millstone quarries of Nieder-Mendig, which have been celebrated for two thousand years. There is a stratum of very hard porous lava, about five miles long by three broad; it is supposed that this lava is the produce of an extinct volcano, and it is found to be admirably calculated for the purpose of millstones. Seven quarries have been excavated, to the depth of about fifty feet; each quarry is a kind of funnel, twenty-five feet in diameter at the top, and twelve at the bottom, with a path cut spirally around it. There is a thickness of fifty feet of gravel and loose lava to be cut through before the quarrymen reach the true stone; and these funnel openings penetrate through this thickness. Arrived at the bottom, the men quarry right and left, forming galleries and passages in all directions. The stone is very hard, and requires good tools, aided by wedges and levers, to work it. There are cracks and fissures which enable the men to separate it into slabs large enough each for a millstone. Hammers and chisels then bring the stones to a proper shape. The workmen form themselves into a kind of working company; taking the offices of miners, lifters, dressers, and loaders, according to their abilities, and sharing the produce among them. Most of the millstones, when made, are conveyed to Andernach, and are there congregated as a cargo for an enormous timber raft, which is floated down the Rhine to Holland; when arrived in Holland the raft is broken up and sold as timber, and the millstones are dispersed whithersoever a market may be found for them.

But France has also a goodly share in the supply of millstones, made from a *burr* stone which is found in that country—so hard and flinty that a pair of stones are sometimes said to work regularly for thirty years before they become worn out. Barley, oats, and rye are chiefly ground, in this country, either with Welsh stones or Derby stones. The Derby millstones are only one-fourth the price of French; but they are so much inferior in hardness and durability, and so much less fitted for grinding wheat, that the French stones maintain their pre-eminence. This French material is seldom found in pieces large and sound enough to make a whole millstone, and it is therefore customary to cement two or more pieces together and bind them round strongly with iron. Practical men differ as to the relative merits of large and small millstones—whether a six-feet stone rotating sixty times in a minute is better or worse than a smaller stone rotating more rapidly, and so forth; but on these matters we say nothing.

The stones used by millers are of various sizes, according to the intensity of

moving power obtainable. Technically, the two stones are called the *runner* and the *bedder;* and the operation of 'hanging a runner,' or adjusting the upper stone over the lower, is one of some delicacy; since not only must the two be rigorously parallel, but the distance between them must depend on the fineness of the flour to be produced and on the rapidity with which the upper stone rotates. Other things being equal, the greater the velocity, the closer must the stones be together, else the centrifugal force would drive away the corn unground or half-ground.

Whatever may be the simplicity or the complexity of the grinding machinery, all corn requires to be *dressed* or *bolted* before it becomes flour. The reason for this is obvious; the bran or husk of the corn becomes mixed with the meal when it leaves the millstones, but it must be separated before we could obtain anything like wheaten bread. In old times, a *bolting-mill* was used to effect this separation; this consisted of a sort of bag made of a peculiar open canvas, in which the meal was thrown; within the bag was a reel revolving with great rapidity, and exterior to it were several bars or beaters; and the action was such that, by the centrifugal force produced by the revolving reel, the flour was driven forcibly through the meshes of the bolting-cloth, leaving the bran withinside. This machine is somewhat complicated, and has been nearly superseded by the *dressing machine.* The latter consists principally of a hollow cylindrical frame covered with wire gauze, increasing in fineness from one end to the other; the cylinder is placed in an inclined position, with the finest gauze uppermost; and revolving brushes are fixed to a central axis in the cylinder. The machine being fed with ground corn, and the axis being made to rotate rapidly, the brushes sift or rub the flour through the meshes of the wire gauze—first through the finest gauze, which only lets *fine* flour pass; then, lower down the cylinder, through the next finest, which allows *seconds* flour to pass; then through two other degrees of fineness, which give exit respectively to the *middlings* and the *pollard;*—until at length, all the meal or flour being separated, the *bran* or husk falls out at the end of the cylinder.

In this, as in many other processes, different persons advocate different methods; some millers separate their flour into four kinds, some limit it to three, while others extend it to five; but in any case there is a corresponding number in the degrees of fineness in the wire cloth, and of shut-up compartments into which the flour falls. The meshes of the wire cloth employed vary from about a sixteenth to a sixty-fourth part of an inch. In some machines there is a still coarser kind, a vibrating sieve, which separates the bran itself into two degrees of fineness.

Certainly one of the finest corn mills in England is that which forms part of the Victualling Yard at Plymouth, in connection with the ship-biscuit establishment. The building which contains the machinery is nearly two hundred and forty feet in length, by above seventy in height. Each wing of which it consists contains twelve pairs of millstones, driven by a steam-engine of 45-horse power; the stones are rather more than four feet in diameter, and make about 120 revolutions in a minute. Each pair of stones can grind five bushels of corn in an hour; so that the whole assemblage could grind twelve hundred bushels in a day of ten hours. The same two steam-engines which work these two groups of millstones also work four wheat-screening machines and eight flour-dressing machines. The corn is deposited in bins on the upper range of the building; from these it passes through screening machines made in a curious manner, by which it traverses a very large surface of wire-cloth, adapted for separating the grains from sand and dirt; it passes thence by spouts

to hoppers which supply the millstones. There are likewise two wheat-drying mills and an oatmeal mill connected with the establishment. To what extent the government supplies of biscuit for the navy are obtained from the flour ground at this establishment we do not know; the ratio probably varies at different times; but as 50,000 seamen require 20,000,000 lbs. of biscuit in a year, the supply of flour from some quarter or other must be very large.

When once the steam-engine is set to work within the walls of a building, there is no predicting where or when it will stay its progress: we may tell what it *can* do, but must be cautious in asserting aught concerning what it *cannot* do. So it is with corn, as with cotton. We are getting beyond the steam mills of the Government Yards. Mr. Bovill, the engineer, has recently introduced improvements of an important kind in the processes of corn-grinding. Simple as this operation seems to be, it is now known that many disadvantages attend the ordinary arrangement of mechanism; and it is to the remedying of these disadvanteges that Mr. Bovill has directed his attention.

To understand the remedy, it will be necessary to notice the defects to be remedied. When corn is ground between two ordinary millstones, the centrifugal force generated by the rotation of the upper stone drives out the meal or flour at the edges of the stone. All the flour thus travels outwards before it can escape from the stone; and in its travels it suffers deterioration. When the running stone has performed even a single revolution, *some* portion of the corn, however small, has been ground into flour; but this portion, instead of escaping at once as it ought to do, is retained among the rest, and is ground over and over again before it can find an outlet at the edge of the stone. The flour which is thus overground is found to be deteriorated in strength and colour; and it is so heated that two or three weeks are necessary before it is fit to pass through the dressing machine. During this lapse of time, any dampness which may reach the over-heated flour tends to produce a slight fermentation, which sours the flour and renders it otherwise out of condition. The damp and heated condition of the flour, aided by our humid atmosphere, renders it necessary to use a dressing machine with coarser meshes than those which are now used by millers in France; we use coarse wire cylinders—they employ meshes of silk; and the consequence is, that a considerable portion of bran becomes mixed up with our flour. Another notable circumstance is, that much flour becomes diffused through our corn-mills, occasioning both waste of property and a deterioration of the atmosphere in which the men are employed.

Now this list of inconveniences is rather a formidable one—the flour weakened in strength, deteriorated in colour, rendered liable to ferment, compelled to lie idle while cooling, imperfectly freed from bran in dressing, wasted in the form of dust, and allowed to pollute the atmosphere of the mill. It is to remedy some or all of these evils that Mr. Bovill's apparatus has been contrived; and this apparatus we may now describe.

In the first place, by a very simple adjustment of a revolving fan, a strong blast of air is directed between the millstones, by which every particle of flour is blown out directly it has been ground, thus avoiding over-grinding and over-heating. The flour falls into a reservoir, and is immediately conveyed by an endless chain of buckets to the room where the dressing machine is at work. Mr. Bovill has discarded the old dressing cylinder of wire meshes and brushes, and has adopted the French system of silk cylinders; his dressing machine is an octagonal cylinder (if such a name may be used), covered with silk, and made to revolve in an inclined position; the bran is

retained in the cylinder, and nothing but fine flour escapes. By another apparatus, the fine flour which is blown out from between the millstones, and *ascends* (instead of descends) by its lightness, is forcibly driven by a blast into a chamber, whose walls are formed of cloth; it is sifted through this cloth by the blast, and collects in the chamber as useful flour. This is the portion which, in an ordinary mill, goes to waste, and fills the air with annoying dusty particles. Thus has Mr. Bovill endeavoured to meet the whole of the evils enumerated above.

An interesting course of experiments was conducted a few months back, in a mill which the Lords of the Admiralty permitted Mr. Bovill to construct in Deptford Dockyard, in close proximity to another mill on the old principle; the object being to fairly compare the two systems. Many gentlemen interested in the welfare of English agriculture were present; and Mr. Bovill commenced by showing, in a remarkable way, how lengthened is the path which a grain of corn is often compelled to follow before it can escape from the ordinary millstones; he placed a piece of French chalk between the stones, and this chalk left an ever-widening circular mark on the lower stone during the revolutions of the upper; the spiral path was no less than 6300 feet long, considerably more than a mile, showing that the chalk had had to traverse this distance before it could escape at the edge of the stone; and an inference may be drawn from this concerning the violent rubbing to which corn is exposed, even after it has been reduced to flour. The comparative experiments yielded the following results: 25 quarters of wheat, half red and half white, were ground and dressed on the old plan; the operations required 9 hours and 50 minutes, and the moving power consumed 2106 lbs. of coal. The same quantity and quality were then treated on the new plan; the time being 6 hours and 30 minutes, and the coals 2464 lbs. The temperatures of the two mills while at work were nearly alike; but the flour as it escaped from the stones in the old mill showed a temperature of 95° Fahr., whereas that in the new mill was only 79°. The relative produce was as follows:—

| | Old system. | New system. |
|---|---|---|
| Best flour . . . . | 9889 lbs. | 9886 lbs. |
| Seconds . . . . | none | 243 " |
| Middlings . . . . | 424 " | 706 " |
| Pollard . . . . . | 894 " | 647 " |
| Bran . . . . . | 611 " | 411 " |
| Money value . . . | 58*l.* 8*s.* 7*d.* | 59*l.* 18*s.* 4*d.* |

It thus appears, if these experiments are to be relied upon, that the new system is distinguishable for yielding seconds and middlings flour rather than pollard and bran; the quantity of fine flour being nearly alike. A little more coal is used in steam-power, but less manual labour is required in the operations. If it be true, as is stated, that three or four quartern loaves more can be made from a sack of flour if ground by the new plan instead of the old, and that as fine flour can be made by the new method from corn at 40*s.* as by the old from corn at 45*s.*—then indeed is this a notable improvement.

The Thames steamers have enabled thousands of passengers, during the year 1851, to witness the exterior of a monster new building, situated between Blackfriars Bridge and St Paul's. This is a corn-mill, lately built at an expense of no less than 80,000*l.*; it contains sixty pairs of mill-stones, driven by a steam-engine of 300-horse power; and it is said to have all the appliances for grinding 1000 quarters of wheat in a day, on Mr. Bovill's principle.

A very convenient kind of corn-mill has been recently patented by Messrs. Garrett. Although portable, it is susceptible of being adjusted either to steam, water, or horse power. The millstones are 32 inches in diameter, and are inclosed in a framing of metal and wood; the shaft which bears the upper stone has a bevel wheel which facilitates its adjustment to the moving power. The stones will grind wheat, barley, beans, or peas; and it is intended for use on large farms, where it would be a waste of time to send everything to an ordinary mill to be ground.

Another ingenious mill of recent introduction is the *Paragon* mill (as it is called) of Messrs. Barrett. It is intended to combine in one portable apparatus the requisite action for grinding, crushing, and splitting, according to the nature of the corn or other crop to be acted upon. Much difficulty has hitherto been encountered in securing these threefold powers in the same machine. Messrs. Barrett have sought this result by employing three rollers, parallel to each other—two in front and one behind; two of the rollers are grooved, for acting on grain or seed, while the other, acting in conjunction with an upright plate, is adapted for splitting beans.

## Machine Bread and Machine Biscuits.

The natural course of our subject now brings us to such modern mechanical arrangements as facilitate the production of bread and biscuits from the flour —whether the latter be ground on the old or the new style.

How the baker prepares his long array of loaves, while those who are to eat the loaves are quietly asleep in their beds, a short description may render plain. Pity it is that the sallow-faced baker is exposed to this necessity: his is an unnatural sort of life, turning night into day, and inhaling an atmosphere very deleterious in its ingredients. Perhaps we may yet see the day when a little additional application of scientific knowledge—a little mechanism in one part and a little chemistry in another—may release our indispensable friend from the bakehouse and put him into a comfortable bed during the hours when bed is most welcome.

Potatoes are used in most modern English bread; they are boiled, mashed, mixed with a little yeast, allowed to stand several hours, strained, diluted with water, and then employed as liquid *ferment*. This ferment is mixed with a portion of the flour to be employed, to make a kind of dough called *sponge;* and this sponge is allowed to rest five or six hours, to rise or swell. More water (having salt and a few other matters dissolved in it) and more flour are added, and the whole worked up by the baker's hands and arms into dough; the dough is left quiet for an hour or two, after which it is cut into pieces, weighed, and shaped into loaves. The oven being prepared, the baker 'sets the batch;' that is, he ranges his loaves in rank and file on the floor of the oven—taking care that the 'cottages' shall not be close together, whereas the 'bricks' are packed up as compactly as possible. Here the bread remains for an hour and a half or two hours, when the hot steaming assemblage is removed from the oven.

Some years ago an attempt was made to establish what (with very little error) might be termed a bread factory, in Leicestershire. There were many novelties introduced by the owner or owners. In the first place the corn passed through two pairs of millstones, placed one over the other; it was partially ground by the upper pair, then fell through a sieve or sifter, and was again ground by the lower pair; and a current of air tended to keep the meal cool.

The objects held in view were, to economize labour, to economize space, and to produce better flour—all very desirable, if to be obtained. Another part of the establishment was devoted to the making of bread. Instead of using yeast, there seems to have been carbonic acid gas injected in some way into the dough, and made to cause the 'rising of the sponge.' The dough was shaped into loaves, which were baked on hollow iron shelves in an immense oven; the waste steam from the engine of the flour-mill circulated in the hollows of the shelves, and heated them sufficiently to bake the bread without further fuel. There were many other projects before the public, about a dozen or fifteen years ago, for making bread on a large and steam-factory scale, and for extracting spirit from the bread; but they all failed—"bread with the gin in it," advertised by the old bakers, succeeded in beating down the new-fangled bread which had been deprived of this alcoholic accompaniment. Dr. Ure says that the quantity of spirit capable of being saved while bread is baking is so extremely small, that the project—instead of being to "take the gin out of the bread"—consisted in "taking the cash out of the pockets" of the shareholders. The Chelsea ginless-bread factory cost 20,000*l.* to establish.

Mr. Perkins' 'hot-water oven' is an American novelty which became familiar to us at the Great Exhibition. There was perhaps a dash of droll quackery in the large loaf exhibited above the oven, and in the small slices of bread liberally bestowed upon the bystanders; the bread *may* have been baked in that particular oven, but the merits of the oven could not be very satisfactorily tested in such a way. The leading principle in this oven is, that the temperature is regulated by hot water instead of hot air, by an adaptation of the hot-water system now so extensively used in warming buildings. There are three merits claimed for this oven by its inventor—*cleanliness*, *economy*, and *ease of adaptation*. It is cleanly, because, there being no coal of any kind used in the oven, nothing but the pure heat from the hot-water pipes can act upon the bread, and no deleterious gases can affect its flavour or quality; it is economical, because, from the mode of applying the heat, one-half of the fuel is saved, and a constant and equable heat maintained; it is easy of adaptation, because the temperature, indicated by a thermometer placed outside the oven, can be raised or diminished at pleasure by opening or closing a damper, so as to meet the requirements of different kinds of baking operations. A very extended application would be necessary to determine the validity of these claims.

There was no lack of ovens at the Crystal Palace which put forth their claims to public notice. There was Mr. Powell's 'portable economical oven.' There was Mr. Shave's 'patent oven for baking bread, &c.,' exhibited for economy of fuel and time. Mr. Edwards' 'atmopyre hoods' are ovens of a somewhat remarkable kind; they are gas-ovens, which act somewhat on the same principle as the wire-gauze envelope of the miners' safety-lamp. They are made of porcelain; gas is introduced into the interior, whence it escapes through small perforations in the sides; these tiny streams of gas, not more than one-fiftieth of an inch in diameter, when ignited on the outside of the hood, burn with a pale blue flame; this flame emits very little light, but its heat is so intense as to make the mass of porcelain red hot in a few minutes. When several of these atmopyres are grouped together, they form a sort of solid fire which will speedily heat an oven; and there are arrangements for adapting the number to the size of the oven required. Porcelain will bear many repeated red-hot firings without being destroyed; and it is at all events interesting to see this beautiful principle (for beautiful it certainly is) of

minutely-divided gas streams applied to the purposes of an oven. Besides our own English ovens, there was M. Espinasse's model of an oven for bread baking, on a new patented system; there was Kaesen's Cologne iron oven; and there was a Chinese oven, heated by the flame of a lamp passing into the centre.

With respect to the ovens ordinarily employed by bakers, the old method of heating by shavings burned in the oven itself has gone very much out of use, being superseded by flues heated in a receptacle distinct from the oven. But it must be owned that the heating of bakers' ovens has not acquired the completeness of which it is doubtless susceptible.

It is rather singular that *biscuits* have become more decidedly a machine-made product than loaf bread. To understand the machine method, we must glance at that which preceded it.

The old method of making sea-biscuits, still adopted by all but a few very large establishments, has much that is rough and uncouth about it. At the great bakery at Gosport, before the machine method was introduced, the men were classed into *furners*, *mates*, *drivers*, *breakmen*, and *idlemen*—odd appellations, some of them. First came the *driver;* the proper proportions of flour and water being put into a trough, he, with his naked and lusty arms, beat and thumped and routed and turned the materials until they assumed the state of dough—a very laborious process this. Then came the *breakman;* the dough was placed upon a platform, a roller called a break-staff, hinged at one end, was placed upon it, and the breakman, riding in side-saddle fashion on the other end of the roller, jumped it about in rather a ludicrous way, giving to the dough a process which was a kind of cross between beating and rolling; very uncouth it was, but it certainly kneaded the dough. Then was the thin layer of dough removed, cut into slices with enormous knives, the slices cut into small squares, and each square worked by hand into the circular form of a biscuit. The biscuits were stamped and pierced, and thrown dexterously into the mouth of an oven, where they fell upon a flat shovel called a peel, and were transferred from the peel to the floor of the oven. This act of throwing the biscuits into the oven, so as to fall exactly on the right spot, became quite celebrated as an act of skilful sleight of hand; and there was, too, a demand for considerable tact in this matter; the biscuits require only a few minutes to bake, and as the oven is kept open during the whole time it is being filled, the men threw *thicker* biscuits in at first than afterwards, that they might not be overbaked. All these latter operations required much skill in the *furner*, the *mate*, and the *idleman*, three of the five attendants upon each oven.

One of the prettiest of all factory operations—a real *factory* operation, although it relates to the preparation of food—which come within the visiting privileges of English folks generally, is that of ship biscuits at our great naval arsenals. There are such factories at Plymouth, at Gosport, and at Deptford; though we believe that, in times of peace, the Plymouth establishment could supply the whole navy with biscuit. Be this as it may, it is asserted that we save many thousands a year by the substitution of the factory system for the old hand system; and that the biscuits are made better, cleaner, and more expeditiously.

If we enter the Plymouth Bakery in the Victualling Yard, at Cremill Point, the scrupulous cleanliness of the whole at once strikes the view; we can hardly conceive that so dusty a material as flour, and so adhesive a substance as dough, can be so tidily controlled. The flour, ground by the steam-mill mentioned in a former page, descends through a shoot into a kind of covered

box, where a small stream of water flows upon it. Then is a whole array of knives set to work within the box, tossing, and dashing, and cutting the mingled flour in all directions by the rapid rotation of a shaft to which the knives are attached; when, lo! in two minutes after the flour has been put into the box, out tumbles 5 cwt. of dough, thoroughly incorporated, but not kneaded. The mass is rolled over and over for five minutes by two ponderous iron cylinders, weighing 15 cwt. each, by which it is thoroughly kneaded. Then does a large cutter nearly sever the thin sheets of dough into six-sided biscuits; then are these cakes of biscuit dexterously placed in ovens; and then, after ten or twelve minutes' baking, are they removed, broken apart by hand, and stored away. Thus is the corn (a mixture of 'fine' flour and 'middlings') converted from the state of meal to that of baked biscuit in something less than half an hour. The men, in their clean check shirts, clean white trousers, clean white aprons, clean white caps, are quite 'pictures of propriety.'

Mr. Harrison's biscuit machine, patented and introduced at Liverpool about three years ago, is a very notable advance on the old-fashioned hand method. Let us briefly describe it as daily at work at the ship-biscuit 'bakery' of the inventor. First, then, the flour and water are placed in a cylinder, where revolving arms toss them about and mix them thoroughly. Then the mixture passes beneath heavy rollers, by which it is speedily kneaded into dough; and this dough is by another roller pressed to the required thickness for biscuits. The sheet of dough travels on an endless apron, and is stamped and cut into the biscuit-form by cutters which descend at short intervals; the biscuits travel on to the mouth of an oven, where they are received on a sort of endless gridiron; the gridiron slowly advances through the oven to the depth or extent of nearly thirty feet, and the heat and length of the oven are so adjusted that by the time the biscuits reach the remote end, they are baked, and fall out at an opening left for them. The oven is heated by hot water. This is a more thoroughly-automatic machine than even the royal baking apparatus at the dockyard; for the flour and water go in at one end of a machine, and baked biscuits fall out at the other.

Messrs. Barrett have constructed a compact apparatus for making what are called Reading biscuits, by the aid of a small amount of steam-power. The flour, water, and other materials for the biscuits, are placed in a trough, and the mixing of these ingredients is effected by causing them to pass beneath a revolving roller; the kneading is effected by other rollers, working over a flat surface; a third set of rollers brings the dough to the state of a continuous sheet of the requisite thickness, and this sheet is stamped out into pieces properly shaped for biscuits.

Thus, then, we see that the manufacturing history of the "staff of life"—though more dependent on vegetable chemistry than most other extensive manufactures—is really coming, year after year, more and more within the domain of mechanics. The horse is helping the labourer, the windmill is helping the horse, the steam-engine is helping the windmill; and the whole together are helping the farmer, the miller, and the baker, to produce more bread from an acre of ground than formerly, to do this with less outlay than formerly, to accomplish the task in less time, and to brave many exigencies of weather which the old-world farmers knew not how to contend against.

# A SHIP, IN THE NINETEENTH CENTURY.

"A ship, in the nineteenth century," is an assemblage of as great a number of ingenious contrivances, perhaps, as any production of man's industry. There is not a science but has been brought into requisition; there is scarcely a material of manufacture but has been employed; there are none of our great departments of manufacturing skill omitted in supplying the ship and her fittings; there is not a quarter of the globe (and scarcely a country on the globe) which has not supplied some one or other of the necessities or conveniences of the floating fabric; and there is no production in which the skill of different nations is brought more distinctly into comparison.

The middle of the present century is distinguished from its opening by the phenomena of steam navigation, above all others connected with ships and shipping; but in numerous other particulars, concerning both the construction and the fittings of ships, the advance has been marked and rapid, showing that the discoveries and improvements in other arts have been promptly applied to those noble structures whose home is to be on the bosom of the ocean.

In noticing a few of the novelties and curiosities presented by this subject, we shall presume the reader to have access, in other quarters, to ordinary manufacturing details respecting the production of ships and ships' fittings: the present sheet is in some sense supplementary to all such details.

## A Bird's-Eye Glance at Ships in general.

And now, at the outset, it may very fairly be asked, how are ships distinguished from boats, and what are the characteristics which separate ships into classes? Many of the modern improvements apply to one class of ships rather than to others; and the answer to these queries thus becomes pertinent to the present subject.

The term *vessel* is more general in its application than *ship;* since the latter, in strictness, is applied only to three-masted square-rigged vessels, consequently to vessels only of a large size. A square-rigged vessel is one in which the sails are suspended from yards fixed horizontally to the masts, usually at right angles to the direction of the keel. Single-decked vessels, with one mast and a bowsprit, but no yards, are called *cutters* and *sloops*, and have the sails generally in a right line with the keel; the cutter having relatively larger sails than the sloop. Two-masted square-rigged vessels are *brigs;* but if there are no yards, and if the sails lie in a line with the keel, the vessels are then *schooners*. Most of the pleasure vessels belonging to the Yacht Clubs are either cutters or schooners. The above appellations are given chiefly to merchant vessels and pleasure vessels, but ships of war are differently designated; they are *ships of the line*, if large, and variously named if small. A

*first-rate* has 100 guns or more, a *second-rate* 90 to 100, a *third-rate* 60 to 90, and so on; *frigates*, *gun-brigs*, &c., are smaller vessels. *Boats* are open or undecked vessels; but some of them are so large, such as the *long-boat*, the *barge*, and the *pinnace* of a man-of-war, that they can carry an armed and well-provisioned body of men on short expeditions. *Life-boats* (not yet adopted so extensively as they should and might easily be) have a buoyancy of construction, which renders it difficult for them to be upset, stove-in, or sunk.

These vessels, however varied they may be in other respects, show how skilfully materials have been combined to make a floating fortress, or a floating warehouse, as the case may be; stability of construction, steadiness of flotation, capacity of interior, swiftness of movement—all are, more or less, combined. As to interior capacity, the *tonnage* is rather a perplexing matter to ordinary readers; we often hear of a vessel carrying a much greater weight of cargo than is indicated by her registered tonnage; while, on the other hand, there is nothing to show whether this tonnage includes the weight of the vessel itself. The case seems to be this—the tonnage is an estimate of the weight of stores and merchandise which a ship can carry without overloading, but does not include the weight either of the ship or its crew and passengers. A 74-gun ship is supposed to weigh, when fully equipped for sea, three times as much as its registered tonnage. Ship-builders and ship-insurers have certain technical rules by which the tonnage of a ship is estimated from its dimensions; but these rules have been altered within the last few years, so that we have now "old measure" and "new measure;" and there are many indications that improvements in ship-building will, ere long, overturn even the new measure, and require the adoption of some new principle of tonnage-measurement.

The greatest ship now belonging to the British navy is, we believe, the *Royal Albert*—still on the slips in Woolwich Dockyard, where it has remained since the keel was first laid down nearly ten years ago. A beautiful model of this ship was prepared for the Great Exhibition, by Mr. Lang, the master shipwright at Woolwich, who designed the leviathan man-of-war. The model was on the scale of a quarter of an inch to a foot.

We may here remark, that the Great Exhibition rendered only scanty justice to the naval architecture of our country. There were models of exteriors, and models of midship sections; there were many interesting novelties, and not a few oddities; but there was no such series as would have compared the early English ships with the modern, or war ships with merchant ships, or steam-vessels with sailing vessels, or screw-steamers with paddle-steamers, or iron vessels with wooden vessels, or roomy vessels with fast vessels, or one kind of rig with another kind, or the craft peculiar to one part of our coast with that observable on another, or the ships generally of our own country with those of foreign nations. There were isolated examples, but anything that could be called a series there certainly was not. A maritime nation might have done better.

If we watch the labours at a ship-building yard, we still find the saw, the axe, and the adze employed in fashioning the timbers with which a ship is built: machinery has yet done little in this matter, owing to the tortuous forms which these timbers are made to assume. There are, it is true, machines now before public notice for cutting these great oaken ribs, and a pretty model of one of them was exhibited in working order at the Great Exhibition; but we must be content to leave to the next generation the gathering of this fruit. In our great ship-yards we still see the draughtsman

make his drawings on paper, and from these drawings chalk out the full-sized curvatures of the ship on a flat boarded floor, and make lath or thin patterns from these chalk marks; the 'converter' has still the office of selecting the oak, and elm, and other woods, and appropriating one piece to one purpose, one to another, according to its size and shape; and the sawyers still cut up the bulky timbers as they were wont to do in past times. Elm for the keel, and oak for the timbers generally, are still the principal kinds of wood employed (always excepting *iron* vessels, of which we have yet to speak). But a notable mark of modern improvement is in the bracing or strengthening of the huge carcass thus built up; diagonal timbers, diagonal plates and bars of iron, are now disposed in the interior to an extent that would quite have puzzled the old ship-builders. And another grand innovation is the *steaming* of such timbers, or rather thick planks, as are to be bent to the curvatures of the ship: a huge iron vessel, supplied with steam, is the receptacle into which the timbers are placed; and here they are steamed and soddened to facilitate their bending.

But what of *mahogany?* Cannot we have our ships as well as our tables made of this beautiful wood? Practical men are beginning to inquire whether mahogany can be effectively thus used, and whether it can be obtained at a sufficiently reasonable price. Until a recent period, nearly all our mahogany was obtained from the West India Islands; and as most of the trees growing near the shore have been cut down, the exigency of land-carriage from the interior has added to the former cost of shipping this valuable wood. The discovery of the riches of California has, however, shed a new light on this subject. Dense forests of splendid mahogany trees spread for hundreds of miles in Central America; and as these regions will shortly be traversed by a railway at Panama, and (perhaps) by a ship-canal at Nicaragua, the forests will be laid open in a way never before contemplated. The trees are at present absolutely valueless, simply because we cannot get at them; but a commercial value will arise as soon as they can be easily felled and shipped. Then will be the time to determine whether mahogany can be bought as cheaply as oak or teak for ship-building. Mahogany is said to be stiffer, less liable to dry-rot, and more buoyant than most other woods used largely in ship-building; and there are records of a few mahogany ships which have shown an extraordinary degree of durability. There is said to be a singular rule adopted at Lloyd's, which, for the present at all events, deters builders from using mahogany, irrespective of the high price which will necessarily prevail until the Nicaraguan forests are laid open: it is, that if mahogany be used instead of oak for certain parts of a ship, the ship ranks "A 1" for only ten years instead of twelve. Possibly the authorities have not yet had sufficient experience of mahogany ships to enable a right judgment to be formed in this matter. And this "A 1" is an important matter to a ship-owner; for it affects the reputation of his ship, the facility with which he can obtain freights, and the rate at which he can have it insured.

We have just mentioned "Lloyd's." Although this remarkable establishment, this mysterious tribunal—which every one reads about, but few rightly understand—is related rather to commerce than to ship-building, a few details concerning it may not be out of place here. More than a century and a half ago, one Lloyd established a coffee-house, in Lombard Street, where underwriters or ship-insurers were wont to congregate; and from that day to this these insurers have acted together as a body, to which the name of "Lloyd's" is given. At present they occupy apartments in the New Royal

Exchange. There is an underwriters' room, a merchants' room, and a captains' room, each of which is opened at a certain annual subscription; and all these subscribers elect the committee which constitutes the governing body at Lloyd's. Underwriters go there to effect insurances on ships; merchants and shipowners go there to seek for such insurances; insurance brokers go there to act both for the insurers and for the insured; merchants and captains go there to consult on their mutual business; and all go there to ascertain every fact which it is possible to collect concerning the merchant shipping of this country. The extent and minuteness of this information are quite extraordinary. Large maps of all the seas on the globe; registers of all the ships in 'Lloyd's List,' of all the occasions when these ships have been "spoken with," and of all disasters which may occur to them; meteorological instruments to determine the state of the weather at all hours in London; tabular statements of the weather from all parts of the world; a collection of nearly all the newspapers from every country;—such are the means provided for carrying on this remarkable establishment. An underwriter makes himself responsible for the safety of a ship, receiving a certain premium for his risk; and he has thus an interest in storing his mind (or his books) with every imaginable record—physical, mechanical, political, and moral—which may affect the fortunes of a ship at sea.

## Novelties and Improvements in Ship-building.

But we must resume our brief sketch of ship-novelties and ship-curiosities.

One of the peculiarities which distinguished early British ships from those of the present day was the great height of the hull out of the water. The *forecastle*, in a modern ship, is anything but a castle; it is the foremost raised deck, very little elevated above the general level. In old times, however, the forecastle really towered up to a great height. So likewise in respect to the *poop*, or hindmost deck: this used to soar to an elevation (in some cases) of fifty or sixty feet; but this has likewise experienced the levelling tendencies of modern ship-building. Our ships are becoming more and more flush from end to end, and the mountain of woodwork above the water is becoming lessened; the round and square ends too are giving way to sharp ends; and the convexities of the hull are being (in many parts) superseded by concavities, which modern science shows to be better suited for cutting through the water. Pictorial representations of the *Harry Grâce de Dieu* (built by Henry VIII.) and the *Royal Sovereign* (built by Charles II.) are to be met with in many English works, and both were represented by models at the Great Exhibition; in these we may see how the old ship-builders piled up poops and forecastles, turrets and bulwarks, until the huge mass almost resembled a feudal castle floating on the bosom of the sea.

But the general arrangement and designation of the timbers of a ship have not undergone much change. We have still the keel, and the stem, and the stern-post; the keelson, the stemson, and the sternson; the bulky masts and the 'steps' or blocks into which they are fixed; the external 'skin' and the internal 'lining' of planks, five or six inches in thickness; the beams and the 'knees' which fasten them to the ship; the 'partners,' and 'coamings,' and 'carlings,' which form a framework between the beams; the deck and its fastenings; and the treenails and bolts.

Masts are still built up in pieces, but a curious novelty has been herein partially introduced. Messrs. Jeffery's *marine glue* is one of the minor aids to

ship-building introduced within the last few years. The claim of the inventor is nothing short of this—that a joint secured by this glue is less easily separable than the actual fibres of the wood itself. In the Great Exhibition were many curious specimens illustrative of the use of this extraordinary cement. One was a piece of the mast of the ship *Curaçoa*, found inseparable even by the wedge. Another was a piece of mainmast, from which a glued fragment was torn away only after a force of 22 tons had been applied. A third was a block of elm, joined with glue; it was exploded by gunpowder, but the joint did not yield. Another was an oak cannon-ball, made of two glued pieces; it had been fired with eight ounces of powder, but the joint held fast. Another was a deal block, which broke in the fibres by a force of four tons. Others were pieces of masts, intended to show how intensely strong a mast becomes when built up with pieces which are joined by this glue. It is not only a glue: it is also a substitute for pitch. Many government vessels have the seams payed or caulked with this glue, which is found much more durable for the purpose than ordinary pitch.

Forest-trees are as chary as ever in furnishing trunks long and thick and strong enough to furnish the largest masts; occasionally the newspapers tell us of such marvels, but they are 'few and far between.' The total length of the mainmast of a '74' is little short of two hundred feet; and it is not only made in three lengths, but each length or subordinate mast is built around with numerous pieces to make up the requisite bulk; why these pieces are known by the elegant names of 'cheeks,' 'front fishes,' 'side fishes,' 'cant pieces,' and 'heel pieces,' the mast-makers themselves must say. Canadian fir is the wood chiefly employed; and of this wood there is no less than six tons in the lower mainmast alone of an ordinary East Indiaman.

If from the woodwork of a ship we turn attention to the sails, we find that one or two improvements have lately worked their way into public favour. The sails are, indeed, a notable part of the attire of a ship—beautiful in effect, indispensable in service. All that the spinner and the weaver, the sewer and the rigger, can do to give them strength is done. Sail-cloth is the strongest of all varieties of the flax manufacture; or sometimes it is of hemp; or sometimes of both combined. The Admiralty is very scrupulous about its sail-cloth, and shipowners have little less reason to be so. A 'bolt' of sail-cloth, forty yards long by two feet wide, weighs from 22 to 44 lbs., according to the thickness; but all alike, stout or fine, are made of these narrow widths. The cutting out for a whole suit of sails is a formidable affair; in an East Indiaman of average size, the quantity of sail-cloth thus consumed is said to be very little less than nine thousand yards. How the cutter-out economises his material, and provides for slanting edges, so as to use up odds and ends in all the nooks and corners, may be pretty well guessed by those who have to cut out any woven goods for garments; but the stitching is a more weighty affair, owing to the great strength required. There is a stipulation between the sailmaker and his employer as to the number of stitches to be put in a given space; and every attempt is made to enable the sail to bear a powerful strain.

A very simple addition has been recently introduced in the means of strengthening the sails of ships. This is by Trail's *storm-sails*. The canvas is the same, the shape of the sail is the same, the mode of sewing is the same; but these sails differ from those ordinarily in use by having strengthening bands of canvas placed diagonally; these bands are corded and are stitched firmly to the sail at intervals of a few feet apart. These bands, by their

diagonal arrangement, tack the various warp and weft threads together, and add very greatly to the strength of the whole spread of canvas. Partially-worn sails, by having these bands affixed to them, take a new lease of serviceable existence, and effect a postponement of the period when new sails become necessary. Independent of any testimonials on the subject, this system carries with it much to recommend it to the judgment; for diagonal bracings, in all kinds of constructions, are yearly coming more and more into use.

Another modern improvement is in the sail-cloth itself. Messrs. Mîlvain, of Newcastle, have devised an ingenious mode of thickening sail-cloth at intervals, by introducing an extra quantity of warp thread; thereby forming bands or straps of very thick twilled canvas, ranged parallel to each other at a certain number of inches apart. These bands cannot loosen, as they form part of the canvas itself; while they add greatly to the strength of the whole.

It is a feature worth noting that ropes—hempen ropes—seem now to have reached nearly beyond the region of improvement. The novelties are rather in the substitution of iron wire for hemp, than in the merits of hempen ropes themselves. This is instructively displayed in the history of Captain Huddart's beautiful cable-making machinery; its excellence is unquestionable, but chain-cables have thrown it out of work. All the world knows how string is made; and a cable is but a reduplication of a multitude of strings. First the spinner, with a bundle of hemp wound round his body, the fibres fastened at one end to revolving hooks, and his hands working busily, spins yarns at the rate of something like a hundred feet in a minute, then a certain number of these yarns are twisted to form a strand; and three of these strands are twisted together to form a rope; and three ropes, when twisted, form a cable. Thus is a bulky cable built up piecemeal, by successive combinations of twisted fibres—each successive twist being in an opposite direction to that which preceded it, so as to lessen the liability of untwisting. In a first-rate cable of twenty-five inches circumference (little other now than a memento of past days) there are three hundred and sixty yarns in a strand.

Little is it to be wondered at if the making of these monster ropes, requiring so much material and so much power, led to the suggestion of rope-making machines. The late Captain Huddart constructed some beautiful machinery for making cables of almost any thickness and any length; and this machinery was to some extent employed by the government; but chain-cables have almost driven these machines into idleness. There is, however, machinery of a most ingenious kind now employed, both by the government and by private manufacturers, in making ropes of smaller size. One such machine must be fresh in the recollection of the visitors to the Great Exhibition; it was Mr. Crawhall's invention, in which the various strands are made to twist round each other by a very ingenious application of rotatory machinery. Ropes and cordage of various kinds, too, we may remark, were not wanting in our international display. There were round ropes and flat ropes, shroud-laid ropes and reef-point ropes, ropes from Russia hemp and ropes from Manilla hemp, ropes made by steam and ropes made by hand, ropes tarred and ropes untarred.

The chain-cables so often alluded to above are simply chains of large size. Our chain-makers take a bar of iron of any thickness, weld this up into links, and at the same time connect these links one to another; and recent en-

gineering has shown that there is hardly any limit to the degree of strength thus obtainable.

And if we turn our glance from the cables to the anchors which they are intended to support, we do not less see the influence of modern ingenuity. Either the anchors themselves have been improved, or the mode of manufacturing them, or both. All throughout the last European war our anchors were fashioned pretty nearly after one model; the various parts—the ring, the stock, the shank, the crown, the arm, the throat, the trend, the fluke, the peak, &c.—had their various conventional proportions to each other; and the technical designations of sheet-anchor and bower-anchor, stream-anchor and kedge-anchor, became familiarised to us as a maritime people. How the anchor was made in those days our dockyard guide-books have not failed to tell, and even our poets and song-writers have versified. The building up of four tons of iron into a first-rate anchor; the welding of bars to form a solid shank; the heating of the iron on the forge-hearth; the fierce blast by which the heat was maintained; the circle of anchor-smiths wielding their ponderous hammers; the sooty dimness, the fiery sparks, and the noisy clangour of the smithy—all have been described over and over again.

But the world has not consented to allow its anchors to remain unchanged: we now meet with many novel forms and appliances. Mr. Pering has shown how to group together a number of broad slabs of iron, instead of mere square bars, to form the shank. Lieutenant Rodgers has been bold enough to propose and to construct *hollow* anchors, on the well-known principle, that a given quantity of material makes a stronger column if hollow than if solid. Mr. Porter has provided a pivot or hinge at the end of the shank, by which the arms and flukes have a certain freedom of movement, intended to facilitate the use of the anchor. The Great Exhibition illustrated these as well as many other novelties in anchors. No one who visited the enclosure at the west end could have failed to notice the enormous anchor sent by Messrs. Brown and Lenox; and there were many curious eyes directed also towards a certain tank or cistern, filled with "unlovely" muddy water, in which two mimic anchors were repeatedly subjected to mimic experiments, to show that a slight alteration of shape produces a considerable result in the grappling power of an anchor.

And the mode of manufacturing anchors has undergone at least as much change as the forms of the anchors themselves. A steam-engine now blows a blast into the forge fire, instead of leaving this service to be rendered by hand-worked bellows. And as to the hammering, this has undergone a complete revolution. A large sort of hammer, worked by ropes, and then a still larger moved by machinery, have had their day; but Nasmyth's steam-hammer now triumphs over them all. Many who saw this machine at the Crystal Palace longed for an opportunity to see it in action; and those who *have* seen it in the anchor-smitheries of our royal dockyards are not likely soon to forget it.

If we pass from the metal of the chain-cables and the anchors to that of the sheathing and the lightning conductors, we find that science, rather than manufacturing skill, has here rendered the chief service. Copper is still the sheathing material, and it is still applied to the lower part of the hull of a ship in sheets, which are fastened with copper nails; and when the ship has seen a certain amount of service, which has worn and injured the metal, the sheathing is stripped off, sold for re-melting, and replaced by new. Our ship-builders have done little more in this matter than to increase the sphere of usefulness due to this system. But in respect to lightning-conductors, the

case is quite different. Year after year did the royal ships and the merchant ships suffer appalling disasters by lightning; year after year did Sir W. S. Harris perseveringly press upon the attention of the government the important fact, that such calamities may be almost wholly prevented. It is only very recently, however, that his method has come into general adoption; but our finest ships have now generally those slips of sheet copper, which, running down the masts and through the hull into the sea, carry off that terrible agent which might otherwise rend and destroy the ship.

A notable modern feature in connection with shipping matters is the *life-boat*—not exactly a creation of our own days, but still one which is now more attended to than ever: witness the Northumberland life-boat prize. The circumstances attending this prize were somewhat remarkable. Notwithstanding all the efforts made by benevolent and enterprising persons, the loss of life on the coasts of England still continues to be seriously large. The storms which rage in the German Ocean, and impel the poor helpless ships towards the shores and shoals, occasion more destruction, perhaps, than those on any other part of our coast. In the winter of 1849 a life-boat, manned by a brave crew of twenty Tyne pilots, was lost while attempting the rescue of a ship's crew; and this, added to so many other lamentable catastrophes, led the Duke of Northumberland to offer a reward of a hundred guineas to the contriver of the best life-boat. So heartily was this offer responded to, that nearly three hundred persons entered the list as competitors; the offer was made in October, 1850; the plans and models were sent to an office in Somerset House, and the Duke collected five folio volumes of manuscript documents relating to them. A committee was appointed to examine all the plans and models; and there can hardly be imagined a trial conducted with more fairness than that which was thus submitted to the committee. Certain qualities were decided on which a life-boat ought to possess; all the competing plans were compared in respect to all these qualities; the relative degrees of excellence in all were represented by numbers, in respect to each quality; and that plan which stood highest in the list in relation to the greatest number of qualities, was adjudged to be the best life-boat. The report of this committee contains the greatest body of information ever collected on the subject. The prize was awarded to Mr. Beeching, of Yarmouth, for having produced the best of all the life-boats.

Mr. Beeching's life-boat is, in form, something like a whale-boat. It is about 36 feet in extreme length, 9½ feet extreme breadth, and 3½ feet in depth; it has twelve oars, double-banked. A cork fender, about seven inches square, runs round outside, at a few inches below the gunwale. Extra buoyancy is given by air-cases placed in all the vacant parts of the boat; these, with the cork fender, give a buoyancy or *upward* tendency of more than eight tons, counteracting to that extent the weight or downward tendency of the boat and its crew. For ballast there is an array of divided water-tanks capable of containing any quantity up to about two tons, and there are pipes for emptying these tanks very quickly. If the boat be upset, the heavy iron keel and the filled water-tanks near the bottom, aided by the light air-cases near the top, tend to right it. It is rigged with a tug foresail and a mizen. The draught of water, with thirty persons on board, is about two feet; the weight of the boat and its fittings is about three and a half tons, and the cost 250*l.* It is capable of carrying seventy persons with safety. In November, 1851, this boat made a trial trip to the Goodwin Sands, under the care of Captain Charlwood and a crew of sixteen picked men; it was placed in such positions

as to allow the surf to have the greatest effect, and the result is said to have been such as to fully bear out the high anticipations formed of the excellent construction of the boat.

Among the competing plans for life-boats were some of great oddity; but none more odd, perhaps, than that which has been displayed at the western end of the Crystal Palace, where the tubs or cylinders provoked a recollection of the oil jars in which the renowned Forty Thieves concealed themselves.

Among the recent projects for life-boats is one that does not relate to the shape of the boat itself, but to the introduction of a particular substance as a buoyant material. This substance is not formally described, but its excellences are announced in most laudatory terms. The 'substance' is made up into packages, and these packages are built into the framework of the boat; it can be applied in any bulk, in any form, and to any part; if a boat be shattered, the pieces, if stuffed with this material, will form so many rafts; the buoyancy is said to exceed that of cork, or even of cases filled with air. In short, if the "Patent Life-Boat, Buoy, Belt, and General Marine Buoyancy Company" do not overstretch their claims, this buoyant material must be a very notable affair; a little incredulity may, however, be wholesome. The substance employed is, we believe, a kind of rush, prepared under a patent taken out by Captain Light.

## Swiftness, as a Characteristic of Modern Ships.

It would obviously be quite beyond the scope of the present paper to go further and further into details respecting modern improvements in shipbuilding and ship fittings. We have said a little respecting the timbers, the masts, the sails, the ropes, the anchors, the cables, the sheathing, the conductors, the boats; but there are almost numberless other directions in which we should find novelties and curiosities, could we search for them. Our ever-busy age would indeed belie itself, were such not the case. Let us, however, before touching on the marvels of steam-shipping, render due justice to the sailing vessels of the middle of the nineteenth century, in respect to sailing qualities.

Speed is the great characteristic of our age in respect to travelling. It is the key which unlocks the mystery of all our modern locomotive arrangements. It shows its power on the water as well as on the land, and in sailing ships as well as in steamers. Many newspaper readers marvel what a *clipper* may mean; but whatever may have been the origin of the name itself, a clipper is simply one of the exemplifications of this speed-producing tendency in modern shipbuilding. The clippers of the German Ocean have arisen thus: when salmon and other perishable commodities began to be sent in large quantities from the north to London, it was found that the clumsy brigs and other coasting craft of the Tyne and Wear were of too slow a movement to convey the cargo with the necessary rapidity. Newcastle, and Shields, and Sunderland, did not want high speed for their coal, and glass, and chemical cargoes; but Aberdeen, and Dundee, and Leith knew how to value any increase of speed for the conveyance of their salmon and cattle, and other articles which became deteriorated by a long voyage. Hence it is to our Scottish neighbours that we are indebted for clippers, or fast-sailing merchant ships. The clipper sacrifices a portion of space for the sake of increased speed; she carries a somewhat smaller cargo than the old vessels of equal length, but conveys it sooner to its destination. The clipper is narrow, gracefully tapering behind, very sharp at the bows, and

altogether calculated to cut cleanly and rapidly through the water, attaining a speed about double that of the old coasting brig. The fruit trade of the Mediterranean and the Azores is gradually coming within the domain of rapid clippers; and the records of daily commerce show us a progressive extension of the same system to ocean sailing.

The opening of the China trade has had a wonderful effect in developing the energies of our ship-builders. Two of the Aberdeen clippers have recently been placed upon the China route, one by a London firm and the other at Liverpool. They are comparatively of small burden, the *Stornaway* being 600 tons, and the *Chrysolite* 450; yet, small as they are, the former has accomplished the out and home voyages between England and China in 102 and 103 days respectively; and the latter in 102 and 104 days—a most extraordinary equality of action. They outstripped three American clippers with which they happened to come into competition, and beat everything else, large and small. It was ascertained about a dozen years ago, by a careful examination of nearly a hundred log-books of Indiamen, that the average time from London to Bombay, in all the ships, large and small, was 112 days. When we consider the much greater distance to China, we shall the better appreciate the remarkable performances of these modern clippers.

This clipper form is unquestionably now of much importance. It was about the year 1840 that Messrs. Hall, of Aberdeen, first boldly adopted—on the wave principle developed by Mr. Scott Russell—a form which combines great capacity with great speed. The *tonnage* of a vessel (as was before remarked) does not now tell us how much cargo can be conveyed; the shipbuilders have managed to obey certain conventional rules, and yet increase the available capacity of their ships. Thus the *Chrysolite* is said to be of 450 tons, yet she brought 900 tons of tea from China. On one day the *Chrysolite* is said to have sailed 320 knots or nautical miles in twenty-four hours. The 'Aberdeen bow' has thus become a very notable recommendation to a ship.

There is, however, a claim put forth by Baltimore to the honour of having introduced the clipper style of ship; at any rate, the 'Baltimore clippers,' usually single or double-masted vessels, had a famous reputation in the western world long before the present rage for high speed arose. Since New York and Boston have sent their beautiful 'liners' to sea, the smaller Baltimore clippers have lost a little of the sunshine of popularity. These larger ships, which cross the Atlantic and the Indian Ocean to China, or double Cape Horn to California, or merely make the now insignificant run to England, have generally some dare-devil name given to them—the *White Squall*, the *Black Squall*, the *Sea Serpent*, the *Sea Hound*, the *Sea Witch*, the *Grey Eagle*, the *Game Cock*—such are the Yankee clippers.

The American 'liners' just mentioned are indeed among the finest ships afloat. They are sailing vessels which ply between England and the United States; and the rivalry of steam has urged their builders to throw the utmost efforts into the construction. At intervals of every few months, or even weeks, the news from the great ports announce to us the launching or the first voyage of some new member of this well-appointed series. Take, for example, the clipper 'liner' *Racer*, which was built at New York, and made her first appearance at Liverpool in the autumn of 1851. Her length is 207 feet; her breadth of beam, 42 feet; her depth of hold, 28 feet; her ''tween decks' height, 7 feet; her load line, 20 feet draught; her registered tonnage, about 1700 tons. She is long and sharp, for speed; but is yet roomy within. On the upper deck, between the fore and mizen masts, is a large and commodious structure,

containing apartments supplied with cooking ranges, a hospital, boys' room, vegetable room, ice-house, &c. The chief cabin is magnificently fitted with all the solid conveniences which mahogany and rosewood can furnish, and all the decorations which gold and papier-maché can supply. In accordance with the American custom of supplying an immense surface of sails to ensure speed, the *Racer* spreads upwards of 8000 yards of canvas. This vessel—so appropriately named—has lately accomplished the run from New York to Liverpool in fourteen days—a speed that throws far in the shade all previous sailing achievements across the Atlantic. But even this has since been exceeded. While these pages are being prepared for press, the *Washington*, one of the 'Black Star' line of packets (for all these companies adopt rather fanciful names), has run the distance from New York to Liverpool in ten hours within the fourteen days.

But it is not only commerce which leads to increase of speed as a desideratum in ship-building; pleasure is also tending in the same direction, as our *yachts* plainly enough show. How characteristic it is, that Robert Stephenson, who has done more to accelerate the speed of travelling than any other man living, should have gone to Egypt in his own pleasure-yacht, the *Titania*, and that this yacht should have been constructed on the speed-producing plan of Mr. Scott Russell, and that the object of the voyage should have relation to the speed of railway transit across the Isthmus of Suez. The man, and the yacht, and the occasion, were worthy one of another.

The yacht *America* is, perhaps, not so noticeable in regard to its own merits as having been the means of drawing a large amount of public attention to the build, the sails, and the rig of ships in general. Belonging to a member of the New York Yacht Club, this yacht was constructed in that city early in 1851, mainly with the view of competing with the English yachts at Cowes. She arrived in this country in July, after a rattling run across the Atlantic; and her shape, her rigging, her sails, all showed marked differences from those presented by English yachts. She was built by Messrs. Steers, for Mr. Stevens, the commodore of the New York Yacht Club. Her extreme length is 94 feet, and breadth about 23 feet. The masts have an extraordinary 'rake,' as nautical men term it—that is, a backward inclination. The standing sails which she carries are those called by sailors the jib, mainsail, and foresail. The internal arrangements comprise state cabins for the master and mate, main cabin, with side berths for fourteen seamen, three or four extra state rooms, cook's galley, pantry, wash room, bath room, clothes room, wine room, sail room, &c.

Such was the vessel which challenged the British yacht owners, and which won the victory on August 22. Then did curiosity set to work in right earnest. Was the *America* built on a new model? Did not the Aberdeen men, or the Yarmouth men, know this build previously? Was she built for comfort as well as speed, like English yachts, or for speed only? Was there a new arrangement of sails? Was the quantity of sail more for the tonnage than in English yachts? Did the 'rake' exceed that in English yachts? Were not the masts less encumbered with rigging than ours? Did her superiority show itself whether sailing with or against the wind, in fair or in rough weather?—All these questions have been canvassed with extraordinary eagerness; and English yacht-builders must be unlike other Englishmen, if they do not show that the discussion may be made fruitful in good results.

## Steam Navigation; its Early Days and its Rapid Growth.

But all improvements in sailing vessels must give way to that which resulted from the application of steam as a moving power. What a scene has half a century witnessed in this matter! It was about 1784 that two Americans, Fitch and Rumsey, exhibited two boats which were slowly propelled in the water by steam power—a humble beginning of a great system. It was in 1788 that Symington, and Miller, and Taylor, applied steam power to work a paddle-wheel; while in the following year they were the first to attain a steam-boat speed of seven miles an hour, on the Forth and Clyde Canal. It was in 1802 that Symington first drew a heavy load along a canal by steam power. It was in 1807 that a steam-boat first plied for traffic from Albany to New York on the Hudson River; this boat, the *Clermont*, was constructed by Fulton, and was of so great burden as 160 tons. It was in 1808 that a steamer first ventured on a coasting voyage, which Stevens made from New York to the Delaware. It was in 1812 that the first passenger steamer plied in Britain; this was Henry Bell's little boat, the *Comet*, of only 25 tons burden, and 3-horse power; it carried passengers up and down the Clyde. It was in 1813 that a steamer first made its appearance on the Thames, as a passenger-boat between London and Gravesend; and it was in the same year that a steamer first braved the rough seas of our coasts in a voyage from Glasgow to London. By the year 1818 there were 46 steamers plying in the twelve rivers—Clyde, Forth, Tay, Trent, Tyne, Humber, Mersey, Yare, Avon, Severn, Orwell, and Thames; and about the same time the steamers in the United States exceeded this number. It was in 1818, too, that the first regular trading over-sea steam navigation commenced, by the placing of the *Rob Roy* on the Greenock and Belfast route; although the English Channel, the Irish Sea, and the German Ocean, had all been crossed by steam before this date. It was David Napier, of Glasgow, who took the lead in steam navigation between 1818 and 1830, and his cousin Robert who has since taken up this honourable position. It was in 1838 that the problem of transatlantic steaming was effectually solved by the safe voyages of the *Great Western* and the *Sirius;* and in the fourteen years which have subsequently elapsed, the progress of steam navigation has been truly astonishing—little less so than that of its sister-system, the railways.

Let us imagine that a 'bird's-eye' glance could be taken at the surface of Europe, in relation simply to the steam-ships which have been mainly established for post-office service. We should see the steamers of twelve Companies, forming an unparalleled fleet of a hundred splendid ships, employed by the English government alone. These ships (it has been lately stated) have cost not less than 3,000,000*l.*; they have 30,000 horse power of engines, and 80,000 tons burden; they traverse 2,000,000 miles of ocean in a year, and their owners receive 750,000*l.* per annum from the British government for postal service. Southampton is the packet station for nearly one-half of these fine steamers; and the three companies which make it their depôt receive much more than one-half of this large sum. If we watch these hundred steamers, careering over seas and oceans, we find that they touch at most of the great ports in both hemispheres; they carry not only British letters to foreign countries, and foreign letters to the British dominions, but also foreign letters to other foreign countries; France, Denmark, Spain, Holland, all have colonies separated from the mother country by the broad Atlantic; but none

of these use their own steamers to perform the mail service to those colonies; it is either effected by sailing vessels, or by the English mail steamers—the latter being the method now adopted more extensively year after year. The West India Company take such mails to the colonies lying contiguous to America; the Peninsular and Oriental Company convey those bound eastward; and in such cases the mail-bags from foreign countries are either brought to Southampton, or we pick them up at Cadiz, or some other port.

The India mail, alone, presents a lively picture of the business-like age in which we live. It is said that the steamers which leave Southampton on the 20th of each month for Alexandria, bearing the Mediterranean and India mails, usually take out as much as three enormous railway vans can contain; there are some two or three hundred boxes or cases of letters and dispatches, and numerous sacks of letters and newspapers—the whole weighing four or five tons, and comprising generally about a hundred thousand letters and twenty thousand newspapers. This, it must be borne in mind, is only one among many monthly steamers; there are five or six others which leave Southampton every month for various ports in the Peninsula and the Mediterranean.

### Wood and Iron Steamers: Paddles and Screws.

But we are somewhat anticipating our subject. There are a few interesting matters to be touched on, relating to the steps by which steamers have reached their present degree of efficiency.

First, then, we have to bear in mind, that steamers were originally all built of wood, that they all had paddle-wheels, and that the boards or floats of these wheels were all fixed parallel with the axis; but these points have undergone notable changes. Our daring engineers have met with equally daring captains, who scruple not to go to sea with steamers "clothed in circumstances" of almost perilous novelty; and the result has shown that this daring has had a sound scientific basis to rest upon.

*Iron* steamers are among the creations of our age. Mr. Grantham, in a paper read before the British Association a few years ago, enumerated so many advantages which iron ships have over those of wood, that it is matter for surprise why ship-builders do not more generally adopt the former material—unless indeed they differ from him in opinion. In the first place, he states that the 'form of least resistance,' which enables a vessel to glide most readily through the water, is more easily constructed in iron than in wood; he thinks that iron ships excel wood in strength and durability, in facility of uniting the various pieces, in comparative stowage, in comfort and convenience, and in expense. In respect to the last-named item, Mr. Grantham adduces the instance of the *Hindostan*, a fine timber-built East Indiaman costing 72,000*l.*, of which the wood alone cost 48,000*l.*; whereas in an iron vessel costing the same sum the crude iron would not be worth more than 5000*l.*—so much more is distributed in wages for the latter than the former. The difference here stated seems excessive; but there can be little doubt that, in a country which yields so abundantly the iron fit for ship-building, great economical advantage ought to result from the substitution of iron for wood, other things being equal. Whatever may be said on other aspects of the subject, it remains on record that the largest steamer in the world —the *Great Britain*—built of iron, was for more than three hundred days lying in peril on the sands of Dundrum Bay; and yet escaped at last with the hull

of iron almost unshaken and uninjured. The commercial misfortunes of this luckless vessel ought not to hide this fact from view.

It must be owned that, when an iron ship is seen under process of construction, it is difficult to realise the fact that it will possess the strength requisite to bear up against the power of the ocean. The keel is formed of bars securely riveted side by side and end to end; a keel six inches deep by three in width being large enough, it is said, for a vessel of a thousand tons burden. The stem-post, the stern-post, the ribs—all are formed of bar-iron, the slightness of which affords a striking contrast to the bulky masses of a timber-built ship. The surfaces are all formed of sheet-iron; and these sheets are fastened to each other, and to the various bars, by a countless number of iron rivets—rivets through the keel, rivets through the ribs, rivets through the sheets, rivets everywhere. There is no soldering, there is but little welding, there are but few screws—all, or nearly all, the fastening is effected by rivets; and these rivets bind the various parts together with almost irresistible force. Of the noisy tumult which the hammering of these thousands of rivets produces in a ship yard, we need scarcely speak; steam-boat tourists on the Thames and the Clyde know something of this matter.

It is difficult to say whether the use of iron in building a steamer, or the adoption of the screw principle for propelling it, has been productive of most advantage. Both are great inventions. The noble *Great Britain*, with her burden of 3000 tons, and her engines of (originally) 1000-horse power, is a screw ship; and the *Screw Steam Navigation Company*, formed in 1846, has fully demonstrated, on the Mediterranean route and the Cape route, that the screw, though perhaps not so swift as the paddle, consumes less fuel and leaves a larger space for cargo. It seems, at first thought, strange that a mere screw, placed at the stern of the vessel just above the keel, should have power to propel a ship. The steam-engine causes the screw to rotate on its shaft or axis, and the blades of the screw enable it to worm its way through the water; but then it should be remembered that these blades are sometimes as much as fifteen feet in diameter, and thus act on the water with immense force.

New screw steam-ships are crowding in upon our waters from all quarters, significantly telling the tale of their efficiency and desirableness. The capacity of screw-steamers, compared with those having paddles, has led to a project of constructing such vessels, of 2000 tons burden, as emigrant ships between Liverpool and New York—a most important circumstance for emigrants, if they can thereby reach the place of their destination in two weeks instead of six or eight.

In the Great Exhibition was placed a model of a screw-propeller, by Captain Carpenter, comprising a very curious arrangement. The fore half of the vessel is like that of an ordinary screw-steamer; but from the midship section to the stern it has *two keels*, placed two feet or more apart, with the water flowing between them. There are two screws, the axes of which are in line with these two semi-keels, one to each, but one a little in advance of the other; and there are two rudders, one behind each screw. Whether this singular project has advanced beyond the condition of a model, we do not know; but the hopes of the inventor are said to be, that the two screws will give a higher speed than one under the ordinary arrangement, and that the two rudders will enable the vessel to turn in one-half of the ordinary space.

The *auxiliary screw* is one of the best of recent inventions. It rests upon the principle that during a favourable wind a ship shall progress by means of

her sails; but that, when bad weather sets in, a screw and a steam-engine shall set to work, and render good service at a time when the poor ship would be otherwise beating about at the mercy of adverse winds, or else absolutely powerless in a dead calm. A vessel so constructed has a screw and engine skilfully placed so as to be out of the way when not wanted, and yet quickly available in time of need; the quantity of fuel carried is but small; while the spare room for cargo is much larger than in any ordinary steamers. Our merchant ships, our war ships, our Arctic exploring ships—are now giving indications that the auxiliary screw principle is rising rapidly in favour. Indeed, it is evident that there are many sources of advantage here in store; for it is optional to the commander to employ steam power just when and as often as he may choose, or his stock of coals may admit. He has wind to appeal to if short of coals; he has coals at command if ill-provided with wind.

From the paddle and the screw we may pass to that mighty agent whereby paddles and screws are made effective—the marine steam-engine—that mechanical unit which had one-horse power in the earliest experiments, and now has five hundred.

The marine steam-engines at the Great Exhibition gave us a little insight into the varied and ingenious contrivances for applying steam power to the propulsion of ships. There was Mr. Atherton's pair of marine engines, having one beam overhead instead of two beams beneath the cylinders, and a construction such as would enable them to be applied either to paddle-steamers or screw-steamers. There was Messrs. Slaughter's pair of 50-horse power engines for a screw-steamer, with cylinders at an angle of 45°, and a three-bladed screw-propeller made of gun metal. There was Messrs. Boulton and Watt's magnificent pair of 700-horse power engines, intended for a screw-steamer, with four cylinders of 52 inches diameter, and a screw-propeller 16 feet in diameter. There were the instructive little models, deposited by the same company, of James Watt's oscillating engine of 1785, and of his experimental locomotive of the same date. There were Messrs. Penn's pair of 16-horse power engines, with oscillating cylinders, such as we are accustomed to see in some of the river boats, and such as have been found capable of high speed out at sea; and the same firm's pair of 30-horse engines for a screw-steamer, of a form now used in some of the screw ships of war. There was Messrs. Maudslay's beautiful collection of models—comprising a pair of beam-engines, such as are largely used in the royal navy, but which are now being gradually superseded by oscillating engines; a pair of these last-mentioned oscillating engines; a pair of the four-cylinder engines patented by this firm, and applied by them to many war-steamers; a pair of annular-cylinder engines, such as are used by some of the steamers on the Folkstone and Boulogne route; a pair of horizontal-cylinder engines, for working a screw-propeller; a steeple engine, adapted for shallow river steamers—such were the instructive contents of the fine glass case containing Messrs. Maudslay's models. There were the curious examples of screw-propellers, deposited by Mr. Smith, who may be regarded as the originator of this mode of propulsion, and whose collection showed how numerous have been the forms of the screw successively adopted: it included the first screw which ever worked a steamer out at sea.

Were it possible to trace all the improvements made in marine steam-engines within the last few years, we should find that not a single month has passed without the introduction of some novelty or other connected with the subject. No part of the complex and beautiful apparatus has been left with-

out its newly-patented inventions, or its registered improvements, or its suggested alterations which have never risen to the dignity either of a patent or a registry. And if we glance through the pages of those journals which record new patents and inventions, we find that there is always some controversy or other going on respecting the merits of certain engines and parts of engines, or whether the 'Fire-fly,' or the 'Fire-king,' or the 'Iron Duke,' or the 'Asia,' or the 'Atlantic,' or any vessel, is worthy of the lofty position which its advocates claim for it. All such discussions indicate the strength of the current of opinion and invention respecting steamers and their engines.

### High Steam-Speed: the Wave Principle.

One of the best gifts which the British Association has bestowed on the practical arts, is the investigation into the nature and forms of waves, and the adaptation of the forms of ships to those waves. Nearly twenty years ago Mr. Scott Russell took up this subject with a view to its elucidation; and in 1837 the Association entrusted to him and Sir John Robinson the management of an extensive series of experiments, conducted at the cost of the Association. Among other results, the Committee discovered the existence of a peculiar wave, generated when a vessel is moving in a channel of definite width; in this wave the particles of water do not merely oscillate up and down as in ordinary waves, but they are lifted forward to a new position, at a rate dependent on the depth of the channel. It was also found that a ship, if it could be made to move with a velocity exceeding that of this wave, will have a tendency to ride on the top of the wave, and to be urged forward with actually less force than if it moved more slowly. A third result was, that if the exterior or water-line of a ship be made to correspond with the shape of this wave, the speed of the vessel will be greater than with any other shape.

In many succeeding meetings of the Association this Committee presented Reports of its indefatigable labours—almost wholly due to Mr. Scott Russell; and those who have not watched the proceedings of that learned body, can scarcely imagine how great and varied were the experiments made by the Committee. Apparatus of the most delicate and ingenious kind was invented for conducting the investigations concerning waves; and when the forms of ships came to be inquired into, the Committee applied to the most eminent ship-builders to mention the points on which they most wanted information, and the forms of vessels which they would wish to have tried. More than a hundred models of vessels were constructed, varying in length from three to twenty-five feet; these were drawn through the water with various velocities, and at different degrees of immersion, to determine the resistance of all the various forms that might be adopted. Some of the experiments regarded the transverse sections of ships; some, the 'water-line' of the bow; others, the water-line of the stern; others, the proper point of greatest breadth, and so forth. Not only were these experiments made upon models, but also upon ships of all burdens, up to 1300 tons. One experiment was very remarkable:—Mr. Russell caused four boats to be constructed, about twenty-five feet long, having all equal length, equal breadth, equal depth, equal capacity, and equal weight; they were towed along at the same time, with the same velocity, and under the same circumstances—nothing differed except the *curves* of the boats at various points in the length. Yet so great was the influence which these curves exerted, that one form met with more than twice as much resistance as another; the other two being midway. The difference of curva-

ture was so slight as to be detected only by an experienced eye, and yet the results were most marked. The boat built on the 'wave principle' was found to be not only the least subject to resistance, but to be the best, easiest, and driest sea-boat. It was also ascertained that each form has a velocity at which its powers bear the most favourable comparison with others; two of the boats, for instance, were nearly equal for resistance at a speed of three or four miles an hour; but one of them gained relatively over the other at six or seven miles speed; the 'wave-line' boat, however, beat all the others at all rates of speed.

A very strange comment on our Admiralty arrangements was made at the Southampton meeting of the British Association in 1846. After Mr. Scott Russell and others had given evidence of the great value of the wave principle in ship-building, Mr. Vignolles, the engineer, asked whether the Admiralty had built any vessels on this principle; and if not, why not? Mr. Russell replied that "he had been much more desirous for the adoption of the system in other ships than in the Admiralty, because he had been informed that the Admiralty did not like the introduction of scientific principles into ship-building, but preferred remaining as they were. He had therefore been averse to obtrude the subject on them."

It is pleasant to know, however, that the same engineer who discovered the wave principle, and who has for sixteen or eighteen successive years detailed to the British Association the results of his indefatigable inquiries, has at last seen even governments (but not that of England) bend to the new order of things. At the Ipswich meeting in 1851, Mr. Scott Russell stated that a foreign government had consented to the adoption of the wave principle in war-steamers. The firm of Russell and Robinson had received an order from a foreign government for two war-steamers, concerning which these formidable conditions were to be fulfilled—"that the ships were to carry double the armament of any war-steamer of the same tonnage and power, and go two knots an hour faster, than any vessel in her Majesty's navy." The conditions, we are told, were faithfully observed, by the adoption of the wave principle in the war-steamers thus constructed. Should the warlike talk of the age ever result in something more than talk, and should the wave principle, or any other scientific principle, be found to have been quietly followed by foreign countries, while our own Admiralty has been reposing on the old familiar customs, the consequence may possibly be neither pleasant to the national vanity nor profitable to the national purse.

What is the proper ratio between the tonnage and the horse power of a steam vessel? This question constantly presents itself to the notice of ship-builders and engineers; but it is quite evident that no settled system is yet agreed upon, for different companies adopt ratios widely diverse. As the race of competition is leading to greater and greater speed, so does this speed lead to greater and greater horse power in respect to tonnage. The English builders generally give a lower horse power per ton than those of the Clyde; but as ocean steamers increase in number, and as adverse tides, currents, and winds occur more frequently in the Atlantic than in sheltered seas, our engineers are gradually adopting the system of giving more power to obtain more speed, which speed acts as a counterbalance to the hostile currents and winds.

What a curious and important subject presents itself to our notice, when we think of the available means for obtaining this so-called horse power! The shaft moves the paddles, and the piston moves the shaft, and the steam moves

the piston; but unless the port from whence the steamer starts is well supplied with coal or other fuel, the length of the voyage has a limit put to it, irrespective of any amount of excellence in the machinery. This was one of the circumstances which led to adverse prophecy respecting ocean steaming, fifteen years ago; the predictions have not been fulfilled, but still the 'coaling' of a steamer is a matter of great moment. Some of our leviathans of modern days carry out a thousand tons of coals with them; but the great desideratum now is, to discover spots where good and cheap coal can be obtained—spots lying in the route of ocean steamers. These spots are being eagerly sought after, and every year adds to the known number of them. Nay, so important is this matter, that it is even deemed worth while to send out coals in other ships to certain stations, in order to keep up a supply for the steamers which call there. One feature in connection with the proposed trans-Pacific steam navigation of the United States merchants is, that the whaling ships, which usually go out in ballast, should go usefully laden with coal, which could be left at depôts conveniently situated for the ocean steamers—a commercial way of "killing two birds with one stone."

Mr. Scott Russell, at the Swansea meeting of the British Association, in 1848, gave a useful outline of the general course of improvements up to that year, in steam-ship building. In the early steam vessels the boilers were of great length, whereby the smoke was kept winding round and round in the flues, and at last was allowed to escape with difficulty. Now, however, the flues are made shorter, very numerous, and of thin metal, so as to heat the greatest quantity of water in the shortest time; by which a boiler of small extent and weight is made much more efficacious than the old bulky and ponderous boilers. The beam-engine, which occupies a great amount of space, was formerly used for almost all steam vessels; but it has been superseded to a very considerable extent by the direct-action engine, in which—the cylinders being immediately under the shaft of the paddle-wheels—less space is occupied, and less power wasted in friction. A useful change also has resulted from the use of oscillating-cylinder engines, which are equally available without a beam. Another important change is, that wrought iron is used in much of the engine work which used to be formed of heavier but less tough cast iron. Many modifications have been introduced in the form of the paddle-wheel and its floats, giving to the latter a more economic action on the water. But a much greater improvement has resulted from driving the paddles more rapidly than was wont in the infancy of steam navigation; it is now known that fuel is economised, instead of wasted, by giving to the movements of the piston in the cylinder, and consequently to those of the piston-rod, crank, shaft, and paddle, this increase of speed. There is a method in practice of 'working steam expansively,' as it is called. Instead of completely filling the cylinder with steam, it is only partly filled, and the tendency of this steam to expand so as to fill the vacuum in the cylinder, supplies in itself a certain amount of moving force, insomuch that a quarter cylinder-full of steam has been made to produce two-thirds a cylinder-full of effect. This expansive working was introduced into steam vessels twelve or fourteen years ago, and the extension of the method has formed one of the marked items in modern improvement.

## OCEAN STEAMERS IN 1852: WHAT THEY ARE, AND WHAT THEY PERFORM.

As an exemplar of the perfection to which the arts of civilised life have been brought into requisition on shipboard, we might take any one of the later steamers built by the Cunard, the Collins, or the West India Companies. All that a seaman can want in the nautical excellence of the ship—all that an engineer can admire in the mechanism for the steam machinery—all that a well-to-do passenger can desire in respect to his own personal comfort—are realised to an extent that the world never saw before. Whether we take the *Asia* or *Africa* of the first of the above-named companies, or the *Atlantic* or *Baltic* of the second, or the *Orinoco* (would that we might also include the *Demerara* or the *Amazon*) of the third, we should equally find this to be the case.

Let it be the *Atlantic*, for instance, which we may select in courtesy to our transatlantic friends. The first American-built steamer which crossed the broad ocean was the *Washington;* but the next one, the *Atlantic*, far excelled it in every respect; it made its first appearance at Liverpool in May, 1850, and formed the commencement of a new era in ocean navigation. Her length of keel is 276 feet; her breadth (within the paddle-boxes), 45; her paddles are 36 feet in diameter, and her floats 15 feet long; her burden is nearly 2900 tons; her power is supplied by two engines of 500-horse power each; her boilers are four in number, each heated by eight furnaces; her appetite for coal is equal to two tons per hour. Then the passenger arrangements are very unlike those of the old steamers. The deck is nearly flush from end to end. The captain and officers' rooms, the kitchen, the pantry room, and the barber's shop, are clustered into two convenient groups on two distinct parts of the deck. The barber's room has a multitude of little handy contrivances for facilitating the delicate operation of shaving during all the varied movements of the ship. On deck also is a smoking room, shielded alike from the saloon below and from the weather above. The saloons are magnificent apartments, each sixty or seventy feet long, by twenty broad; one we may call the dining-room, and the other the drawing-room. They are fitted up with every imaginable luxury. Rose-wood and satin-wood, carving and gilding, mirrors and stained glass, velvet cushions and rich carpets, brilliant silver-plate and lustrous cut glass, paintings and sculptures, polished marble and polished steel, abound in the fittings and furniture. There are a hundred and fifty berths, situated on either side of the saloons, besides a certain number of 'wedding-berths,' which, in accordance with a general custom in America, are provided in steamers for newly-married couples who wish to pass the honeymoon on the waters. Bells are placed in all the cabins, or rather a bell-rope in each, all communicating with a bell-telegraph, such as was shown in our Great Exhibition. A bell likewise gives the signal from the captain to the steersman, who steers to the right or the left, according as one or two strokes are given on the bell. A kind of bell-rope, but with an inscription-card instead of a bell, is used to convey signals from the captain to the engine-man below; according as the orders 'go on,' 'slow,' 'fast,' 'ease her,' 'stop her,' or the like, are needed to be given, the captain pulls one or other of several handles, which causes the required signal to appear on an inscription in the engine-room. One little appendage makes its appearance in the saloons and other elegantly-fitted places where we should little expect to meet with it: it

is a concession to a certain habit in which Brother Jonathan indulges to a considerable extent—this appendage is a *spittoon*.

There is scarcely need, in this place, to dwell at any length on the magnificent steam fleets belonging to the companies alluded to in many of the preceeding paragraphs. All alike have availed themselves of those grand improvements which so signally mark the steam navigation of the present day. If we trace the history, or visit the ships of the '*Cunard*' or the '*Collins*' lines of North American steamers at Liverpool; or of the *Peninsular and Oriental*, or the *West India* lines at Southampton; or of the *Ocean Screw* lines at Plymouth, we find that all now comprise truly magnificent vessels. A burden of 3000 tons, a length of 300 feet, an engine-force of 1000-horse power, are no longer isolated wonders in our ocean steamers.

When shall we cease to ask for higher speed? The world ought, perhaps, to be satisfied with being conveyed from Liverpool to Halifax in eleven days; yet does the recent Galway enterprise (and many other projects) show that men will not be content until the shortest practicable ocean route is attained. Liverpool is not the most western British port; Halifax is not the most eastern American port; hence are the projectors looking around for others. Many an eye has been attracted by the favourable western position of Galway; and since a railway has been formed from Dublin to that port, Galway has put in its claim to the dignity of a transatlantic mail station. Galway is, perhaps, two hundred miles in advance of Liverpool on the way to America; and there is a small port called Sydney, in Cape Breton, seventy or eighty miles nearer to Europe than Halifax; and hence it has been proposed to establish a mail route from Galway to this little Sydney. Supposing, however, Galway and Halifax to be selected, this distance of about two thousand miles might, as is hoped by sanguine projectors, be accomplished in seven days. But until railways are further advanced in British America, Galway must look to New York rather than to Halifax as the other end of her oceanic chain; and a few months will probably show us something notable in this direction.

And it is in a somewhat analogous spirit that we should regard the competing schemes for ocean routes to India and Australia. Shall it be by the Isthmus of Suez, or by Panama, or by the Cape? Which is the shortest? Which will convey our officers, and colonists, and merchandise to the far-distant east most quickly and cheaply? All these questions are being narrowly canvassed; and it is not improbable that the result will be the establishment of all three routes—each having its own catalogue of favourable circumstances, and the impulse of competition having taken so decided a form. If we do *not* effect these things, America will; and herein is another source of commercial activity.

How strangely does it strike upon the mind—how subversive of old-time associations—to read such an advertisement as the following:—"Steam Communication between Cairo and the First Cataract. The Egyptian Transit Administration begs to inform travellers that a steamer will be dispatched from Cairo to Assouan on or about the 10th of every month. . . . . . The whole voyage will be accomplished in seventeen or eighteen days, including about 210 hours' stoppages at all the places where the principal antiquities exist." Napoleon talked to his soldiers about forty centuries looking down upon them from the Pyramids; but if the builders of Edfou, and Denderah, and Thebes, could "look down" upon a puffing, panting creation of "Penn and Sons," or "Maudslay and Co.," rattling audaciously along at the very

foot of the sacred temples, the sight would be much more startling than that of an armed host, and more significant of the progress which the last hundredth-part of forty centuries has witnessed.

The fine steamers of our day are not to be understood by regarding merely their mechanical and engineering qualities. There are other commercial curiosities exhibited by them. For example—*food.* Of that part of a ship's accompaniments which relate to the victualling of the crew and passengers, no example, perhaps, is more striking than that afforded by the great mail steamers which leave Southampton every month. One of the Oriental steamers sometimes contains a crew of nearly a hundred, and about as many passengers; these have to be provisioned for five weeks; and the principal portion of this supply is shipped at Southampton. Grocers, butchers, bakers, wine merchants, spirit merchants, confectioners, poulterers, cheesemongers—all are busy for several days before the starting of the mail, in supplying provisions, which comprise the delicacies as well as the solid comforts of the larder and the cellar. "About 3000 lbs. weight of bread, flour, hops, and malt," says a writer in the *Hampshire Advertiser*, apparently well informed on this subject; "2000 lbs. of butchers' meat, consisting of prime beef, mutton, pork, calves' heads, and ox tails; 200 head of live stock, comprising sheep, pigs, turkeys, geese, ducks, fowls, and a cow in milk; 100 head of dead stock, consisting of turkeys, geese, ducks, fowls, and rabbits; 2000 lbs. of provender for the live stock; 3000 bottles of champagne, claret, Madeira, port, and sherry; 6000 bottles of pale ale, porter, soda-water, and lemonade; 200 gallons of brandy, gin, rum, and whisky; 3000 lbs. of tea, coffee, and sugar; 2000 lbs. of various groceries and spices; an immense quantity of oilmen's and confectioners' stores, such as anchovies, blacking, bottled fruits, candles, cod-sounds, curry powder, celery seed, groats, herrings, jams, jellies, marmalade, maccaroni, mustard, salad oil, olives, pearl barley, pickles, capers, salt, sauces, salt fish, catsup, soy, soap, soda, salted tripe, vermicelli, whiting, vinegar; together with 1000 eggs, and 1000 lbs. of bacon, butter, and cheese;—are shipped on board every Alexandrian packet at Southampton, for one outward and homeward voyage." Of course in a large man-of-war, provided for a long period, the quantities of provisions must be very much greater; but we are speaking of ordinary monthly commercial systems.

One word as to the millions of steam-boat passengers. The new Navigation Act, which came into operation on the first day of 1852, contains many important regulations for the safety of passengers. An Act of Parliament is not omnipotent, either in the prevention of accidents, or in anything else; but a ship-passenger is so helplessly and hopelessly at the mercy of others, that it becomes reasonable for the legislature to try and throw a shield of protection around him. What, then, are the materials of this protecting shield, as set forth in the new Act? In the first place, all steamers are to be surveyed twice a year by surveyors appointed by the Board of Trade; these surveyors are to examine everything, in the departments both of the shipwright and of the engineer; they are to send in their report; the Board (if the report be favourable) is to give a certificate, and without such a certificate no steamer must commence its six months' liberty of voyaging. In the next place, all our steamers must have transverse water-tight partitions, between the engine-room and the fore and aft parts of the vessel, respectively; a latitude being allowed in respect to ships already built. Then, again, self-acting safety valves are to be provided to every boiler of every steamer, placed out of reach of any interference from the engine-man. Another clause determines the minimum number and the

dimensions of the boats which shall be carried by every sea-going vessel, whether sail or steamer; one of these boats, too, to be a life-boat. As a further precautionary measure, hose for fire engines, and blue lights, and a cannon for signals of distress are to be provided. And lastly, all accidents to steam-boats are to be reported at once to the Board of Trade. Such is the statute. Three days after it came into operation occurred that deplorable calamity to the *Amazon*, which was the first subject that came officially under the notice of the Board. We may observe, however, that the ocean mail steamers, being already under stringent contracts, are not amenable to the Board of Trade under this new Act.

### Ships and Shipping at our Great Commercial Ports.

The advance of any of our great ports, such as Glasgow or Liverpool, is in itself one of the best indices to the advancement of shipping arrangements generally. Taking Glasgow as an example, what do we see? We have there a river on which a million and a half sterling has been expended; in forming embankments, building two miles of masonry quays, straightening the crooked bends, deepening the bed so as to receive ships of a thousand tons burden, fixing beacons for twenty miles down the river, providing sheds and cranes and all other apparatus to facilitate the loading and unloading of ships; by such means has the Clyde become one of the most wonderful rivers in Britain; and on the banks of this river are situated those great foci of industry where our steam ships have received so much of their development. Here are to be found the works of Robert Napier, of Tod and Macgregor, of Caird, of Wood, and of other distinguished firms, whose names are so indissolubly bound up with the progress of modern navigation.

If we glance at Liverpool instead of Glasgow, the shipping phenomena are still more astonishing. Here we find a range of docks more than four miles in length; in which there are sometimes as many as eight hundred ships moored at one time; and the construction of which cost twelve millions sterling. Liverpool is now the greatest port in the world, in respect to the value of its exports, and the extent of its foreign commerce generally. New York, the first city in the United States, is more populous, but its commerce does not equal that of Liverpool. The shipping trade is rather less than that of London, but the exports amount to greater annual value. These amounted, in 1850, to the almost incredible sum of 35,000,000*l*., much more than one-half of the whole exports of the whole United Kingdom! They comprise not only the cottons of Lancashire, but also the woollens and linens of the West Riding, the salt of Cheshire, the coal of Yorkshire and Northumberland, the pottery of Staffordshire, the hosiery of the midland counties, the steel of Sheffield, and the iron, the hardware, and the machinery of all our midland and northern counties.

According to returns recently prepared, it appears, that 4440 vessels entered the port of Liverpool in 1851, of which rather less than two-thirds were British, and the rest foreign; their burden amounted to upwards of a million tons. The ships which departed from Liverpood rather exceeded this number. In everything relating to maritime and commercial affairs, this extraordinary port claims our attention. So many nations have dealings with Liverpool, that there are more than thirty consuls there. The customs receipts in 1850 were nearly 3,400,000*l*., and in 1851 they exceeded 3,500,000*l*. In ship-building, besides all the sailing vessels and all the paddle steamers,

there were no less than 18 screw steamers built at Liverpool in 1851, presenting an average of about 500 tons burden each.

And if we take our wondrous metropolis, and the river on whose banks it lies, we encounter, of course, more vast and varied phenomena. In 1850 a lecture was published by Mr. Howell, entitled 'A Day's Business in the Port of London.' He selected one particular day in September, 1849, and procured a mass of Custom-house documents in respect of that day's commerce on the Thames. We find, then, that 121 ships, navigated by 1387 seamen, and having an aggregate burden of 30,000 tons, arrived in the Thames on that day; of these only one in eight were foreign vessels. They came from all parts of the globe, as far north as Archangel, as far south as Australia, while the remote east and the "far west" supplied their fair quota. These ships contained 300,000 lbs. of sugar, 16,000 chests of tea, 7400 packages of coffee, 3000 head of live stock, 8000 packages of butter, 50,000 cheeses, 900,000 eggs, 4458 bales of wool, 1250 tons of granite, 219 packages of specie, 80,000 lbs. of currants, besides smaller quantities of almost every conceivable article which commerce brings to this country; all this, be it remembered, is one day's arrival at one port. It was not all, however, for home consumption, since London is a spot on the great highway of nations where merchandise rests for awhile on its transit from one country to another. There is no reason to think that the day selected was an unusual one as to commerce, or that it presented other than average amounts; nor is there any mention here of the departure-ships with their cargoes, nor of the immense coasting trade between London and other British ports.

Our shipping account for 1850 is one of which the nation has no little reason to be proud. In it we find that 23,960 ships were registered at British ports at the close of that year; that the burden of these ships amounted to 3,337,752 tons, or about 140 tons per vessel on an average; that our merchant steamers were 570 in number; that 27,286 ships left British ports for foreign countries, and about the same number entered British ports from those countries; that about 5000 ships left for the colonies, and rather more than this number arrived from the colonies. But the coasting trade, in which each vessel generally makes many voyages in a year, involves numbers and quantities almost incredible. The parliamentary returns tell us, for instance, that, in the year now under notice, all the voyages of all the coasting vessels in the United Kingdom amounted in number to more than 140,000; this being the number of vessels which 'entered inwards,' as the maritime authorities term it; the number 'entered outwards' being of course nearly the same. During that year 610 timber sailing vessels, 18 timber steamers, 11 iron sailing vessels, and 50 iron steamers—making a total of 689—were built, or finished building, and were placed upon the registry.

Let us here do justice to the young but energetic power beyond the Atlantic. Her fine yachts and 'liners' have been adverted to, and her 'Collins' steamers have been described; but her commercial marine must not be thus briefly dismissed: it is certainly among the most remarkable phenomena of this age. We may pardonably boast a little of the general advance of British shipping; yet the United States beat us hollow in *rapidity* of advance. In 1832, just twenty years ago, the shipping of the United States amounted to a little more than 1,400,000 tons; while in 1850 it reached 3,500,000—a rate of increase very far exceeding that of the British commercial marine. In the year ending June, 1850, we are told (by the government statistics) that no less than 18,195 vessels left or arrived at ports in the United States, of which rather less than

one-third belonged to the republic—the larger moiety belonging to other countries. More than six hundred of these cleared from the comparatively modern port of San Francisco; but from New York—the queen city of the western hemisphere—the arrivals and departures reached 7303, averaging 20 per day. At the close of 1850 it was calculated that there were not much fewer than 2000 steam-boats navigating the rivers and lakes of America, and 22,000 American steamers and sailing vessels, of various kinds, on the coast and on the broad seas. More than 1300 vessels, great and small, were launched in the republic in 1850. The city of New York, in nine months of that year, launched 12 large steam-ships, 7 steam-boats, 13 liners or first-class sailing vessels, and 5 smaller vessels; while at the end of this period there were on the stocks, in the building yards of that city, 12 large steam-ships, 5 steam-boats, and 14 other vessels of various kinds; making, together, a total of 68 vessels, either launched or building; and of such magnitude were some of these ships, that the average burden (taking one with another) exceeded 1000 tons.

Many circumstances have led to this rapid advance of American shipping. One of the most notable of these is the supply of cotton to Britain and other parts of Europe. The astounding extent of this commerce is treated in another paper of this series (COTTON AND FLAX); and it may well be supposed that the conveyance of nearly two million bales across the Atlantic yearly, with 300 to 400 lbs. of cotton in each bale, must needs require many large and well-appointed ships. Another is, that as any large sale of commodities between two countries leads to nearly equal purchases in others, by which the 'balance of trade' is pretty nearly kept up, the sale of cotton *to* England has led to vast purchases of manufactured goods *from* England, which furnish valuable freight for shipping. Another circumstance is, the acquisition of California by the United States, followed by the discovery of the golden wealth of that extraordinary country; mighty, indeed, is the activity which this has given to American shipping. Let us lastly note a few of the recent statistics of emigration, so far as they affect shipping. In 1850, then, the number of emigrants from British shores was 280,849, of whom no less than 257,663 sailed for America. Not only did Liverpool excel any other British port as the point of departure, but it far exceeded all the others taken together, the number from Liverpool being 174,188. The amount of shipping employed in conveying this great number of souls across the Atlantic is really very large. In the four years 1847 to 1850 there were 2166 ship-loads thus conveyed to search for a new home from Liverpool alone, comprising nearly 600,000 persons, or an average of about 275 in each ship. Nine-tenths of these emigrants were Irish, who crossed St. George's Channel to take ship at Liverpool. Great as was the number of emigrants shipped from Liverpool in 1850, it became still more surprising in 1851, when it was little short of 200,000.

Of the horrors which have occasionally been experienced by these poor emigrants, when eight or nine hundred have been cooped up in one ship (which has occasionally taken place), we need not speak; the emigrant regulations are now far superior to those formerly adopted, and dishonesty on the one side and misery on the other diminish in amount.

It is impossible to avoid seeing that "a ship, in the nineteenth century," is one of the most notable aids to the 'fraternisation' of different and widely separated countries.

# FIRE AND LIGHT: CONTRIVANCES FOR THEIR PRODUCTION.

If we look around us it will speedily become apparent that the artificial production of *fire* and *light* forms a very large and curious department of commercial industry—full of ingenious contrivances, bold enterprises, and uncertain speculations. The precarious search for whales in the Greenland Seas and the Pacific Ocean; the wholesale slaughter of oxen for the sake of their tallow in Russia; the busy collecting of palm-oil in Central Africa; the burrowing of miners through hundreds of miles of subterranean galleries in search of coal; the vast shipping and commercial arrangements for transporting the oil, the tallow, and the coal from place to place; the erection of the numerous and extensive structures for obtaining gas and coke from coal; the subway arteries through which this gas is conveyed to our streets and houses; the lamps for applying the oil, the candles for applying the tallow, the burners for applying the gas, and the stoves for applying the coal; the complex mechanism for warming extensive buildings; the enormous furnaces and ovens for applying heat to manufacturing purposes—all tend to show that man's labours in the production of fire and light are both varied and extensive.

Nor are these subjects less marked than others by curious attendant circumstances and ingenious modern inventions. A few of these will here engage our attention.

### Coal; Coal Fields; Coal Mines; and Colliers.

The mode in which the inhabitants of a country habitually warm their dwellings must obviously depend on the kind and quantity of fuel which they can readily obtain; and no inconsiderable effect on the internal arrangement of dwellings is traceable to this source. The wood-fuel districts have their characteristics, differing from those of coal districts, and both differing from those in which fuel of every kind is scarce.

It is instructive to compare the fire-places (if thus we may call them) of different countries and different ages. There is the Laplander, with a large lamp of stinking fish-oil in the centre of his hut, the flame and smoke of which supply him with his only fire during the long Arctic winter. There is the Persian fire-pot, or *kourey*, containing some slowly-burning fuel, and covered with a large quilt, beneath which the family tuck their feet and legs to obtain warmth. There is the open vessel containing burning charcoal—often a medium for displaying great elegance in the braziers and tripods, but always a dangerous contaminator of the air. There is the Chinese system of hollow walls and tile-made flues, through which hot air passes from a stove containing a compost or mixed fuel. There were the open fire-places of our

feudal halls, with the andirons for supporting the burning brands, the louvre-boards in the roof for the escape of smoke without admitting rain, and the somewhat savage grandeur which the glare of light threw around the hall. There were the fire-places of a later date in our old English manor-houses, where an enormous chimney replaced the louvre-boards, and in which warm seats were snugly ranged around the cheerful fire. There are the numerous and varied contrivances consequent on the substitution of coal for wood-fuel. There are the close stoves of the Continent, some made of metal and some of clay, but all repugnant to our English notions of a cheerful open fire. There are the economical novelties for producing small fires for minor purposes; and the culinary novelties for employing gas, or spirit, or naphtha, instead of coal; and the scientific novelties (sometimes failures) for warming our large public buildings.

Many may, perhaps, now with difficulty realise the state of things when coal was *not* used among us as a fuel; yet such a time of course existed; and it is not difficult even to name the period at which a commencement was made. This period was rather more than six centuries ago, when the neighbourhood of Newcastle was first explored for coal; and from that time, during many hundreds of years, discoveries were gradually made in our northern counties of valuable beds of coal. At first the "homes and hearths" of Englishmen would not receive the black sooty fuel; it did not suit the fire-places or the domestic habits of the people; but it was found well adapted for the blacksmith and the lime-burner. Only the layers near the surface, and in coal-fields adjacent to rivers or seas, were first opened; but when the demand increased, the miners dived more deeply into the bowels of the earth, and boldly worked the coal wherever it was to be found. When the mines became deep, the miners were sadly perplexed how to get rid of the water; and it was not till the steam-engine came to their aid that they fully mastered this difficulty. But the prejudices of the users were as difficult to surmount as the perils of the miners; we are even told of a period when a citizen of London was tried and executed for burning sea-coal, in opposition to a stringent law passed in respect to that subject; but even long after such intolerance as this had passed away, coal was *tabooed* in good society. Ladies had a theory that the black abomination spoiled their complexion; and it was for a long time a point of etiquette not to sit in a room warmed by a coal fire, or to eat meat roasted by such means. Prejudice unquestionably had much to do with these objections; but it was not all prejudice, for the almost total absence of proper arrangements for supplying fresh air, and removing smoke and foul air, rendered the burning coal a very dirty and disagreeable companion in a room.

Coal, however, became at length our national fuel; and whatever may be the other sources of the wealth and commercial prosperity of Great Britain, most certain it is that our ample supply of coal is one of the most notable. It is conducive not only to the domestic comfort, but to the manufacturing efficiency of the people. It brings into a useable form not only the crude mineral productions which lie embosomed in the earth, but various other sources of power which would else remain dormant. It supplies not only all our own wants, but is the basis of a large and remunerating commerce with other countries. It not only obviates the necessity of cutting down the residue of our fine forests and woods for fire-wood, but it throws a life of industry and activity into districts which would else be profitless moor and mountain land.

It is indeed remarkable that so small a country should furnish so mighty a supply of fuel. We have 12,000 square miles of coal area—nearly one-tenth of the entire area of our island; but still this bears but a small ratio to the total quantity in all countries. According to the estimates of Professor Ansted and Mr. Taylor, the ascertained area of all the coal strata in the world is not less than 150,000 square miles. And yet the annual amount of coal worked and brought to light in the British Islands is nearly double that of all other countries taken together—so enormous are now our colliery operations. The number of coal-fields in these islands, comprising districts detached from all others, is about 30; the number of distinct workable seams in these coal-fields varies from 1 to 84; the thickest-seam in any one field varies from 3 to 40 feet; and the aggregate thickness of all the seams in each field varies from 3 to 200 feet. From these various coal-fields there are now extracted not less than 35,000,000 tons in a year—the value of which, including transit to the place of consumption, is about 18,000,000*l.* This estimate, of about ten shillings per ton, may seem small to Londoners, accustomed to a price so much higher; but in all the coal-mining and iron-smelting districts, the average is far under that here named. Of the 18,000,000*l.*, it is supposed that about one-half is the value at the pit's mouth, and the other half the value of the transit to the consumer. The fixed capital employed in the coal-trade, including mining machinery and transit machinery, is roughly estimated at 10,000,000*l.*

The Newcastle coal-field is that with which the inhabitants of the metropolis have had principally to do, owing to the overwhelming preponderance of this coal in use in London. Of the half million acres of coal in this field, about seventy thousand have been now worked; at a consumption of ten million tons a year, it is supposed that this field will yet last eight or nine hundred years. Some of the Northumberland and Durham pits are nearly two thousand feet deep; there are about two hundred separate collieries, which employ nearly thirty thousand men and boys, besides those engaged in the transit by sea and land.

The recent celebrated Exhibition was full of instructive examples not only of the coal which we possess, but of the mechanism for bringing it to the surface. The visitors, British and foreign, will not soon forget the huge masses which the west end of the building displayed. There was the Coed Talon block of Flintshire steam coal, worked into a pillar, and said to weigh sixteen tons (a cubic yard of coal, we may here state, as affording a convenient means of calculation, weighs about a ton). There was the magnificent block of Tipton coal, thirteen tons weight, taken from the 30-foot seam of South Staffordshire, and being the largest piece which could be drawn up through a seven-foot shaft. There was the large block of Welsh anthracite from Cwmllynfell. There was the unequalled Staveley block from Derbyshire, seventeen feet long, six wide, and four thick, and estimated to weigh twenty-four tons; it was drawn up from a depth of 460 feet. There were many others which would have appeared monsters but for the vicinity of this wonderful specimen from Staveley.

The mechanism for working the coal, too, we have said, was well illustrated. In one instance, there was the rope by which one of the huge blocks was raised, and the picks and chains used in the mine. Another instance was a built-up column of the Staffordshire thick coal, showing the different working-seams as they exist in vertical section. A third presented to us a model of the apparatus used for the shipment of coals from boats or waggons at

Cardiff, worked by a high-pressure steam-engine, and enabling vessels to ship 400 tons a day. There were models of the corves or buckets, and of the working tools employed by the Silkstone colliers. There were elegant vases formed of Ince Hall cannel coal, exhibited to show rather the qualities of the coal itself than the mode of working it; and there were similar nicknacks, comprising pillars, small boxes, stamps, chessmen and boards, bracelets, shirt-buttons, razor hones, &c., formed from a brownish coal recently discovered near Edinburgh. The Tyne Coal Committee sent a map of their coal-field, showing the pits, the railways, and the 'faults' in the seams; and sections of the field, with a synopsis of the seams; also a working plan of a colliery, including both the mining and the ventilating arrangements; and lastly, models of the various implements employed, together with one or two of the safety lamps. A similar excellent series of models and sections was sent from a Staffordshire colliery. A particularly interesting series of the same kind was that relating to the strata and workings at Ebbw Vale in South Wales.

In our English coal districts, as in most others, the beds of coal, whether few or many feet in thickness, are usually found inclined more or less to the horizon; but the workable beds are at all depths, from a few yards to six hundred yards beneath the surface. The mode of working must necessarily, therefore, vary considerably according to the depth. In nearly all cases, however, there are vertical shafts dug from the surface till they intersect the bed of coal; and from the bottom of these shafts horizontal galleries are worked in the substance of the coal. The galleries themselves yield coal while being excavated, and they also afford access to the rest of the mass. But as this process of excavation, if carried on incautiously, would leave the roof of the mine, or the earthy layer above the coal, unsupported, the colliers are careful to leave substantial masses of coal as pillars or columns. When about one-third of the coal is thus extracted, and the maintenance of the colliery workings is no longer necessary, the colliers carefully break away the supporting masses and allow the roof to fall in as it may. The method of mining here described is called the *pillar and stall* method, and is adopted in Northumberland and Durham; but in Yorkshire and some other districts the *long-wall* method is acted on; this consists in removing the coal entirely and at once, the roof falling behind the work as it advances. Where the coal is near the surface, as in Staffordshire, the falling in of colliery roofs has given extraordinary irregularity to the surface of the ground; so much so, indeed, that many of the miners' houses require to be propped up, as if undermined by earthquakes. The whole of the soil of South Staffordshire may be said to be honeycombed by this cause.

## Colliery Perils, and their Remedies.

There is a curious chain of links which connect living wood with dead coal. First, there is *peat*, consisting of various kinds of plants and moss, imbedded and pressed together into a mass, and exposed to the action of air, or water, or both, and perhaps heat, for unnumbered centuries. Then there is *lignite*, formed in nearly the same way from trunks of trees, and accumulated in layers of vast thickness in Germany and other parts of Europe; it has not hitherto been much used as fuel, but there are indications that it will so be ere long. Next comes *jet*, which appears to be a peculiar variety of vegetable matter brought almost to a bituminous state. Then we have *cannel coal*,

which not only yields the best and most abundant gas for street-lighting, but has often such a hardness, blackness, and polish, as enable it to be worked up into very beautiful ornaments; many persons will remember the garden chair and the model of the Durham monument, in cannel coal, at the Great Exhibition. Next is the *caking coal* of Newcastle and its neighbourhood, which combines so many useful qualities for household purposes. Somewhat different from this is the *stratified coal* of the midland counties, which is obtained in very long pieces, and has less bituminous or caking quality than the Newcastle coal. A still less gaseous coal is that which, from the purpose to which it is now found to be admirably adapted, is called *steam coal;* it is obtained chiefly from Wales, and burns with intense heat and little flame or smoke. Last on the list is *anthracite,* so nearly without gas as to consist almost entirely of carbon; its intense heat and freedom from sulphur render it invaluable for iron smelting and other manufacturing processes.

Most of the kinds of coal enumerated in the above list are mined or procured in a similar way; but those which contain the largest ratio of gas are those from which danger most fearfully results to the miners. Newspaper readers need not to be reminded of the sad details which corroborate this fact; and it is impossible to look without interest at any contrivances which may lessen the calamities to which our swarthy coal-miners are subject. As the impure state of the air in the mines leads to disastrous explosions, so does the great depth of the mines entail great liability to fatal accidents. That men should descend and ascend a quarter of a mile of ladders every day, is a wonderful instance of patient daring; but if they descend by any kind of mechanism, their safety is too often dependent on a single rope. It is to obviate disasters of the latter kind that Messrs. Fourdrinier have invented a very ingenious apparatus lately brought before public notice. It consists of a basket or cage, which may contain either coal itself or the men who work the coal. It is raised and lowered through the shaft by a rope worked in the usual way from above; but it also slides in vertical grooves at the sides of the shaft; and these grooves afford means for safety in the event of the rope breaking. Should such a mishap occur, two arms or levers throw themselves out, and catch against the grooved guide rods so firmly that the basket becomes held fast, and is prevented from further descent. The apparatus has been repeatedly tried in the collieries of the north, and seems to have been very generally approved. It would be a great pity if, as in the fire-escape, the good which the apparatus might render, were rendered of non-effect by any neglect in the use of the machine itself; being essentially a *preventive* agent, and not a mere cure after the evil is produced, nothing but a pre-adoption of the apparatus in moments of safety could test its value in moments of disaster.

But it is from explosions, rather than falls, that coal-miners suffer disaster. There is a liability to the accumulation of gases which are deleterious and even dangerous to those working in the mines; and very extensive systems of ventilation are adopted, by which fresh air is made to pass through all the passages and shafts of the mine. It is from partial neglect, in otherwise good systems, that many of the disastrous explosions have occurred.

Mr. Nasmyth's recently-invented fan seems to be a notable instrument for aiding the ventilation of mines. The use of a revolving fan for such a purpose is an old idea, generally realised by using the fan as a blowing machine, to force fresh air down a shaft into the mine; but Mr. Nasmyth, the inventor of the famous steam-hammer, conceiving that it would be better to draw bad air

out of a mine than to force fresh air in—or rather that it would be *easier*, and that fresh air would be sure to follow to fill up the vacuum—devised a new form of apparatus. Above ground, near the 'up-cast' shaft, a steam-engine and a revolving fan are erected, and a pipe to connect the fan with the air in the shaft. The shaft is made to rotate rapidly; it sucks the air from the 'up-cast' shaft (which is always impure); and the vacuum below just as rapidly sucks pure air down the other shaft, and thus a circulation of air is maintained. A fan, four or five feet in diameter, and rotating 400 times in a minute, will send down 20,000 cubic feet of air *per minute* into a mine; and there seems no reason why a larger fan should not be made capable of pouring down a flood four or five times this amount. Nasmyth's apparatus is of very recent introduction: and we believe that the inventor has abstained from patenting it, with a view to encouraging its use in coal mines, where some such contrivance is sadly wanted.

Another recent and ingenious novelty is the invention of Mr. Struvé, and has been brought under the notice of the Institute of Civil Engineers. His apparatus consists of two hollow pistons, resembling large gasometers, and two cylinders in which these pistons work. The hollow pistons are, in reality, air-reservoirs, with valves at the top and bottom. The cisterns are nearly filled with water; and the arrangement of the valves is such as, when the pistons have a reciprocating movement, to fill them with air by one movement, and to force the air out of them by another. A small steam-engine suffices to work the apparatus, and a pipe conveys the forced air to the shaft of the mine.

One of the most singular incidents in the recent history of coal mines is the extinction of a fire in a Scottish mine. In the South Sauchie Colliery, a few miles from Stirling, a fire has been raging for nearly thirty years; a nine-feet seam of coal, twenty-six acres in extent, has thus been in a state of devastation, and has been known in the neighbouring districts as "the burning waste of Clackmannan." The fire is supposed to have been caused by some persons who established an illicit whiskey-still in the old workings. When it was found that no ordinary means would extinguish the fire, a sum of 16,000*l.* was spent, and five years employed, in building a mud wall around the burning mass, so as to deprive it of all access of air: the builders of this wall had to struggle against their fierce opponent for the mastery, being driven further and further away from the centre as the fire spread. So important has it been to keep this mud wall in repair, that the proprietor of the mine (the Earl of Mansfield) has since had to spend many additional thousands of pounds, besides losing the value of the coal in the mine. The seam is at a small depth only beneath the surface; and as the external air was thus able to effect an entrance in small quantities through fissures in the ground, it kept up a slow, sulky, smouldering combustion, occasionally made manifest by the escape of smoke through cracks in the ground.

Thus matters remained until recently, when the Committee of the House of Lords on colliery accidents collected much valuable information bearing on this subject. Among other instances, it was found that Mr. Goldsworthy Gurney had effectually extinguished a fire at the Astley Collieries, in Lancashire, by a new and very singular operation. In the early part of 1851 Mr. Gurney undertook to extinguish this extraordinary Clackmannan fire, and most effectually he accomplished it. His plan consisted in pouring down into the mine an immense body of choke-damp, forced in by a high-pressure jet of steam; the quantity being sufficient to extinguish the fire, the temperature

low enough to cool the coaly mass, and the pressure intense enough to keep out all external air. A furnace was constructed above ground, capable of burning coal and coke; a boiler was erected to supply steam; flues and pipes were so placed as to convey the gas and steam to one of the old working shafts of the mine, and a hole was broken through the mud wall below to establish a communication with the smouldering mass. The fire was lighted; the choke-damp (a mixture of carbonic-acid and nitrogen) was generated; the steam was brought up to a high pressure; and a jet of steam being admitted into the pipe which conveyed the choke-damp, forced it irresistibly along and into the mine. For several hours was this flood of gas poured in, until the mine contained eight million cubic feet; it was completely filled, and remained so for three weeks. The absence of free oxygen in choke-damp 'put out the fire,' and a subsequent stream at a lower temperature cooled the mass; then fresh but damp air was admitted, and was forced for some weeks through all the vacuities of the mine, by which it was found that the temperature lowered a little every day; and at length, on fairly opening the mine, the fire was found to be utterly extinguished. This was perhaps the most successful conquest over the burning element ever achieved.

But it is not to put out a fire—it is to prevent a fire from kindling, that miners are more frequently called upon to show their ingenuity. If they could see to work without lamps or candles, few or no explosions would happen; but the darkness of the mine prevents this: hence, among other means, we have the 'Davy,' or 'safety lamp,' a beautiful contrivance, but one which has not kept the miners free from fearful calamities. How far this has resulted from their own carelessness is still a disputed point. The huge masses of coal give off carburetted hydrogen gas; this gas combines with the air which enters the mine, and at a certain ratio of mixture the two gases or airs explode when a light reaches them. Hence the coal-miner is never quite safe; he is either liable to be burnt by the *fire-damp* or gas, if this explodes, or to be suffocated by the *choke-damp*, which is one of the results of the explosion. Hence the earnest desire to prevent any naked flame from reaching the gas, and hence Sir H. Davy's highly-scientific mode of lighting the miner without perilling his life. If a fine iron wire gauze surround a flame, no flame can pass through the meshes; unignited gas may, but flame cannot. Herein lies the whole principle of the 'safety lamp.' It is a simple oil lamp, with a wire-gauze envelope around the flame. Fire-damp may get *into* the enclosed space, through the meshes, and may there burn; but the produced flame cannot get *out* of the space, without which it could not ignite the gas in the mine generally. It is a fearful thing, to those who know what has occurred and is likely to occur in mines, to see a faint blue light within the gauze space. This shows that the mine is full of fire-damp, that some has entered the lamp, and that the least failure in soundness or in carefulness will lead to an explosion. Dr. Clanny has improved upon Davy's lamp, insomuch as to enable it to give a better light and to act more safely. Mr. Goldsworthy Gurney, too, has recently directed his attention to the miners' lamp—not so much, however, with a view to its safety, as to enable it to yield more light to the miners. He states that three-fourths of the light of an ordinary Davy lamp is lost by the use of dull iron-wire; but that if the wire were plated and polished the loss would only be one-eighth. Ingenious persons are constantly endeavouring to make these safety lamps really safe; but yet the 'Colliery Explosions' are fearfully numerous, and there is every reason to believe that these mining lamps are not looked after so sedulously as they should be.

## Charcoal; Coke; Peat; Artificial Fuel.

The coal-fields, the collieries, the miners, their lamps, and their disasters, must not hide from our view the existence of other kinds of fuel, the preparation of which exhibits many curious features.

We have outlived the days when charcoal was needed in England for fuel. A little is made, it is true, for special uses; and for some purposes charcoal is the best of fuel; but it is on the Continent that its production forms a regular and extensive department of manufacture. As in tanning leather, so in charcoal-burning, there are quick as well as slow processes; and experience seems to show that the slow methods produce better results than the more rapid. Various modes are adopted in making charcoal on the Continent. In one very common method, the billets of wood (oak, beech, alder, birch, fir, &c., according to circumstances) are built up horizontally into a hemispherical mound; the mound is well packed in with turf and charcoal powder; a fire is kindled in the centre of the bottom of the mound, through holes left for the purpose; by due management of air-holes the wood is allowed to give off its moisture by slow evaporation; and then commences the charring process, by which little is left in each billet but carbon. According as the mound varies from ten to sixty feet in diameter, so would this charring require a week or several weeks for its proper completion. In another mode of proceeding, the billets are built up into a long quadrangular mass, and the air-holes are differently managed; but the general nature of the process is the same. Where the charcoal-burner wishes to save some of the liquid and gaseous products of the wood, he conducts the operations in a regularly-built furnace, so arranged as to separate and preserve the tar.

In one of the busiest parts of Rhenish Prussia, there is a manufacturing district which illustrates in a very striking way a state of dependence on charcoal-fuel. Near the town of Siegen, a sparry iron-ore is found, which is well adapted for making steel, when smelted with charcoal; and a flourishing steel manufacture was established at Siegen many centuries ago. The princes of the house of Nassau sought to establish a monopoly of the manufacture at that spot, for their own pecuniary advantage. A compact was entered into by them with the smelters, so far back as the year 1478, whereby the latter undertook not to carry their art out of those districts, under pain of forfeiture and death; in return for which pledge the smelters received certain privileges, which were renewed by charters from time to time. After a time it was found that this concentration of operations at one spot thinned materially the forests whence was obtained the wood for making charcoal for the furnaces. Then came another 'protective' measure—that prohibiting the exportation of charcoal; and then followed a third—that of limiting the number of smelting works, in order that no one of them might consume too much charcoal. To this succeeded a fourth stage in the same train of operations—that of prescribing the exact number of days in a year which each furnace should work.

As the distillation of wood leaves charcoal as a solid residue, so does that of coal leave *coke*—a commodity which our locomotive system is rendering very valuable. It is a curious circumstance in respect to the demand for different kinds of fuel for different purposes, that coal is made to yield two such kinds—utterly different one from another, and both in full demand as rapidly as they can be made. We of course allude to *gas* and *coke*. Let

a ton of ordinary caking coal be subjected to the usual process of the gas-works: what are the products? About eight or ten thousand cubic feet of invisible carburetted hydrogen gas, and ten or twelve hundred weight of dull, hard, brittle coke. The gas takes nearly all the hydrogen of the coal; the coke nearly all the carbon; and the one is fitted to yield more light than heat, while the other is valued rather for heat than light.

As there is much more coke required for locomotive and other purposes than the gas companies can supply, coke ovens are established expressly for the manufacture. Fortunately, small coal is as effective for this purpose as large, and thus the waste heaps at the mouths of the coal-pits become available. Many of our great railway depôts have ranges of ovens expressly designed for making coke. The coal is thrown into these ovens, kindled, closed in from the air, and allowed to smoulder for thirty or forty hours; arrangements are made for burning the gases, so that they may not pollute the air; and the solid residue is the coke, which supplies fuel to our countless locomotives. In the open country districts the coke-ovens are often much less complete and much more wasteful than those at the great depôts. It is a curious circumstance, and illustrative of the changes which the carboniferous structure undergoes, that the coal increases in bulk by getting rid of its gas; eight sacks of coal will yield ten sacks of coke.

One of the curiosities in coke is that, although so granular in appearance, some of the particles have almost the hardness of the diamond, and are found fitted for cutting glass.

Across, in the sister island, another fuel may be seen. One-seventh part of the surface of Ireland being covered with *peat*, it becomes an important question to determine whether this peat can be usefully applied, and the ground beneath it brought within the range of agriculture. Many plans are now in partial operation for expelling the moisture from peat, and rendering it a useful fuel; most of these plans operate by pressure; but one is an application of centrifugal force—now brought into requisition in so many and such remarkable ways. Sometimes peat is exposed to combustion in close chambers; the volatile products are applied to various chemical purposes, and the solid residue forms a kind of charcoal or coke. The great question in such operations is, will they pay? They are practicable, we know, but will they yield a commercial profit, when all expenses are paid? The same question may be asked, and is often asked, respecting the application of any kind of machinery to the simple pressing or drying of peat. Practically, peat can be pressed to a density exceeding that of coal, and in that state its heating power is very considerable. Mr. Vignolles, the eminent engineer, has recently found that the peat to be met with in many parts of Germany may be made into excellent coke, by a process of his own introduction; and he has since taken out a patent with a view to a similar commercial project in Ireland. Poor Ireland! it would be a worthy application of modern science and mechanism if her bogs could by such agency be converted from useless blots into fruitful sources of wealth. A 'British and Irish Peat Company' has been lately formed (or at least attempts have been made to form it) for the reclamation of bogs in Dartmoor and in Ireland, and the application of the peat to useful purposes; besides the formation of fuel, it is known that naphtha, paraffine, fixed oil, volatile oil, acetate of lime, sulphate of ammonia, and other chemicals, can be obtained from peat, and flaming accounts have been published of the probable profits derivable from a manufacture of such articles from such a source; but there is much reason for believing that the estimates are

greatly exaggerated. So of peat-fuel, too; we know that fuel can be made from peat; but many circumstances must come into view in determining the commercial success of the plan.

It is curious to note how many new 'patent artificial fuels' there now are. As experimenters tell us that different kinds of coal and other natural fuel possess different qualities, an inducement is offered for the exercise of ingenuity in devising various imitative compositions. The hydraulic press is brought into singular requisition in this art. Thus, Azalay's hard shining blocks of artificial fuel are simply formed of coal-dust subjected to intense compression. Mr. Warlich's patent fuel, in large-sized bricks weighing about twelve pounds each, is made by mixing together the dust of various kinds of coal; the bricks are dense and well made; the fuel kindles slowly, but gives off very little smoke while burning. Mr. Warlich's series comprises Welsh steam fuel, north-country fuel, household fuel, and locomotive coke-fuel—differing in the kind of coal-dust used, and in the amount of tar with which the dust is agglutinated. Warlich's patents are worked by a company, who have establishments at Deptford, Swansea, and Middlesborough. The Bideford Anthracite Company make artificial fuel, in brick-form pieces, by a particular mode of treating anthracite. Oram's patent fuel is a condensed mixture of small coal, bitumen, and sand. Williams's fuel is a mixture of dried peat and bitumen. So of numerous other kinds; small coal, bitumen, or peat, or two out of the three, are mixed with various other substances to form a compost fuel. It must be owned, however, that such fuel is not yet much used.

## Stoves; 'Smoke-Nuisance;' Cooking and Warming Apparatus.

Surely never before were there produced such varieties of stoves as those which now glitter in our drawing-rooms. The display is a striking evidence of the combined luxury and comfort of our modern fire-places. If, too, we pass by the elegant productions of Sheffield, intended for the parlour and the drawing-room, and attend only to those cooking arrangements with which the kitchens of club-houses and large mansions are now supplied, we shall find much that is really curious and ingenious. There is Mr. Flavel's 'kitchener,' in which one fire-place is made to do the ordinary work of three; in which the ovens might be applied to roasting instead of baking, by modifying the admission of air; in which the hot closets might conveniently be converted into pastry ovens; in which the top of the apparatus presents a multitude of contrivances for minor culinary operations; in which the back is formed by a boiler of fifty-gallon capacity—in which, to sum up, every particle of heat is as much as possible made to render up its quota of service. There is Messrs. Benham's large range, similar to that supplied by them to the Reform Club-house; with its intense radiating heat for roasting, its Stourbridge fire-clay back, its bars on hinges for interior cleansing, its frontage capable of variation in size, its steam closets and hot plates, and all the other numerous appendages. There is Mr. Sherwin's range, closed or open in front according to choice, with its oven having flues all around it, and its ample supply of hot water and steam. There is Duley's apparatus, in which the heating of the oven is ingeniously aided by a hollow shelf through which the hot air passes. There is Cornell's cooking range for schools, in which no less than sixteen spits are provided, each prepared for the impaling of a separate joint; and in which the bars are formed of hollow pipes always filled with water. There is Grant's 'cottager's stove,' intended to give a useful fire to a working-man's

home at a very small expenditure of fuel. In short, the kitchen ranges and cooking apparatus of our day are really scientific productions; the radiation, the conduction, and the ascensive power of heat are all attended to.

A marked change is now observable in the arrangement of stoves in our best apartments. The burning mass is now placed very near the ground; it thus warms the stratum of air which is most exposed to chilly influences, and is sure to warm the upper strata afterwards, by the natural tendency of heated air to ascend. The diagonal and concave reflecting surfaces by which these new stoves are surrounded, constitute another notable improvement; the brilliant lustre thus produced is by some persons deemed merely ornamental; but it has a deeper meaning, and is really an application of a well-established scientific principle. Nay, to so nice a point is this principle now carried, that a *conical* reflecting surface is supplied in the grates for small rooms, while a *parabolic* surface is adopted in those to be placed at the end of a long room; the latter form being adapted to reflect out rays of heat to a distance. In our ordinary fire-places the ugly ash-pit obtrudes itself far too conspicuously into notice; but in those now under consideration, it is scarcely visible, and in some is entirely out of sight. There are thus four merits attributable to the stoves which now grace our drawing-rooms—they warm a lower stratum of air than can be warmed by ordinary stoves; they reflect nearly all the heat out into the room, allowing little to ascend the chimney; they remove the unsightly ash-pit into a desirable obscurity; and they afford a scope for infinite variety in the tasteful designs for the reflecting surfaces around and beneath the fire-place. It is impossible to avoid seeing that our Sheffield designers, as well as those of London and Birmingham, are striving earnestly to throw an air of grace and elegance over the stoves and fire-places now produced. As the 'fire-irons' are a necessary part of the apparatus for an open English fire, attempts are now made, more successfully than formerly, to give them an artistic connection with the stove itself, as if all formed component parts of one design. Some whimsical combinations result, it is true; some are too delicate for coal-dust and ash-dust; but many are unquestionably graceful applications of dead bronze and dead iron, polished steel and polished brass. It has been whimsically said that not a few of these elaborately-decked stoves "would require an artist to clean them instead of a housemaid."

The tendency which heated iron has to decompose the air, or rather the miscellaneous floating particles which ordinary air always contains, has led to the suggestion of employing fire-brick or fire-clay instead of iron to form the heating surfaces. Mr. Juckes and Mr. Leslie have recently introduced very ingenious stoves on this principle.

When will stoves and fire-places, chimneys and flues, be made to 'consume their own smoke?' Society calls aloud for this to be done; and yet the demand is but little attended to. As an example of the mode—one among many—by which furnaces may be made smoke-consuming, we may adduce that patented by Mr. Juckes. The question to be practically answered is this—how to subject the smoke from coal to intense heat before it is allowed to enter the chimney? In an ordinary open fire-place, the cold air from the room enters the vacant space above the bars, and there cools the smoke too much to admit of any combustion. To whatever degree a furnace admits of a similar defect, to that degree will it 'smoke.' Now, in Mr. Juckes's arrangement, the fire bars are linked together in an endless chain, which chain passes over two wheels or drums at the front and back of the furnace; the chain is

made to travel onwards from front to back, at the rate of six feet in an hour. On this chain of bars the coal is placed, so that the bottom of the fire-grate is constantly moving. The coal is deposited in a reservoir in front of the furnace, and from this reservoir it falls into the furnace as the bars travel on. Thus the fiercely-blazing fire is between the new cold coal and the flue at the back, insomuch that the smoke from the coal is compelled to pass through the fire, and to be there consumed; thereby increasing the heat of the furnace instead of sending a jet-black cloud of rich but wasted carbon into the atmosphere. The furnace is fed with air through the bars, and the clinkers or hard cinders fall out when the bars have travelled to their hindmost position. The inventor tells us that economy results not only from the consumption of the smoke, but also from the facility for using small and cheap coal; that the heat and steam-producing power are rendered more regular by the steady and self-acting feeding with coal; that labour is saved by the fire-bars clearing themselves as they travel onwards; and that increased cleanliness may be maintained by this contrivance. Practical men can alone determine how far these are the real characteristics of Mr. Juckes's plan; but the scientific principle on which it is based seems clear and intelligible. Many other inventors have systems for ensuring the same ends; and the Legislature is doing what it can to stir up the energies of the furnace-makers and furnace-users to a similar purpose. An Act came into force in London on January 1, 1852 (and local Acts with the same object have been procured in several of the great manufacturing towns), for inflicting penalties on the owners of such factory chimneys as are not made to consume their own smoke. Bricklayers and builders, too, are trying their best to cure the household malady known as a 'smoky chimney:' there is the 'self-acting chimney-guard' of one inventor, the 'double-chambered smoke-preventing chimney' of a second, and many other recent contrivances, intended to apply to this much-talked-of discomfort.

There are a few fire-places of small dimensions—curious for their very smallness—which call for a meed of notice. M. Soyer, whose 'Gastronomic' and 'Symposium' novelties have placed him somewhat out of the range of ordinary *chefs de cuisine*, invented a 'magic stove' or 'cooking lamp,' a year or two ago, which is certainly ingenious, whether or not destined to have a successful career. It is in effect a spirit lamp, with a novel mode of exciting and maintaining combustion. There are two reservoirs of spirit, which may be alcohol, or brandy, or naphtha; and there are two lamps. You light one lamp with spirit from one reservoir; the flame of this lamp heats the spirit in the other reservoir; the vapour from this heated spirit pours out in a continuous but gentle blast into the midst of a second flame, which flame heats the cooking apparatus. There are thus two distinct halves of the apparatus, one of which is destined to feed the other half with hot spirit vapour instead of cold air, for keeping up ignition; and the heat thus produced is singularly intense. Whether this 'magic' contrivance will bear out its character of "superseding inevitably every contrivance which ingenuity has hitherto devised for the rapid preparation of a comfortable meal;" whether it will cost "only three farthings to dress a cutlet;" whether you may "cook as comfortably with it in the middle of a stiff nor'-wester as if the sweet south were wooing your cheek in June;" whether "a mutton chop is dressed by it to a nicety in six minutes;" whether these newspaper encomiums are well founded—each user must decide for himself. In some forms of the apparatus the whole mechanism for cooking a dinner for six persons—including stove, lamp, stewpan, frying-pan,

saucepans, plates, dishes, tea-kettle, and coffee-pot, are packed into a space of less than one cubic foot—a *multum in parvo* this, of an extraordinary character, it must be admitted. The apparatus, however, with its nicely-fitted copper appendages, is rather costly.

There are other contrivances, humble relations of the same family. The 'bachelors' kettles,' and 'bachelors' ovens,' and 'bachelors' kitchens,' are now so numerous, that those said bachelors ought to be grateful for the attention thus bestowed upon them; but, in truth, if a cooking apparatus be efficient for a small scale of operation, it matters little by what name it is called—it will work its own way into favour. Besides the 'magic' contrivance of M. Soyer, there are many others of small size in which spirit, wood, or gas are employed as fuel. In Mr. Rigby's 'pocket stove,' for example, there is a small reservoir of spirit, from which a gas or vapour rises; and this gas supplies the requisite heat. Mr. Hulett has exercised his ingenuity in the production of a number of 'gas-cooking stoves,' 'gas-kettles,' 'bachelors' cooking apparatus,' &c., in which ordinary gas is the fuel employed. In Mr. Norman's small cooking apparatus there are two saucepans or vessels, one within another, with a vacant space between filled with water; and the inner vessel is thus heated by a sort of hot-water jacket. In other contrivances the 'patent fire-wood' (itself one of the most curious examples of modern search for convenient novelties) is made to render service of a similar kind.

And if we pass from the smallest kind of heating contrivances to the largest, we there find that hot air, hot water, and hot steam are applied by means of apparatus both curious and costly. Dr. Arnott's pretty contrivance of a close stove may be classed among those which heat buildings by hot air Let a fire be lighted, for instance, in such a stove; although one particular outlet must be left for smoke and gases, yet an enveloping chamber, whether of metal or of fire-clay, would contain a body of warm air, and this air might be conducted by pipes to any part of a building. It was Dr. Arnott's ingenious expedients for regulating the heat of the stove, rather than the principle of the stove itself, that was novel. There is the 'cockle' or Belper stove, invented by Mr. Strutt, which has such a reservoir of warm air as we have here alluded to, and a pipe to convey it to distant rooms. There is the Derby stove of Mr. Sylvester, in which the same result is carried out by improved agency; and there are other modifications by other engineers and inventors.

The method of steam-heating, now very largely adopted, depends on a principle not so easily recognisable as that of the hot-air system. A pound of steam contains an immense amount of heat more than that contained in a pound of boiling water; so that the contents of a boiler, if flashed off into steam, and made to travel into a system of pipes in that form, is in itself a rich calorific reservoir. When the steam comes into contact with the cold metal of the pipes, it is condensed again into water, and liberates the heat which had been imprisoned in it; this heat first warms the pipes, and then diffuses itself among the air in the room or gallery containing the pipes. James Watt knew well the properties of steam in this respect, and he was just the man to give to those properties a practical application; he first warmed his own study by such means, and pointed out how others might do better. Then came in succession the plans (some of them patented) by Hoyle, Green, Boulton, Lee, and others, differing in the mode in which the steam was conveyed to the rooms, or in some of the minor arrangements, but agreeing in principle.

The steam-method, however, has not had a long or active life; it is yielding to the hot-water method. This consists in having a boiler, in some convenient spot, and a long coil of iron pipe leaving the boiler at one spot and entering it again at another; the intermediate length of pipe being carried up or down, in or out, according to the position of the rooms to be warmed. It forms a rude analogy to our own bodily circulation; the boiler is the heart, while the pipes are the veins and arteries. If the boiler be placed in a low position, the water in it, when heated, has a tendency to rise; and if the whole system of pipes be filled with water, the rising hot water drives the cold water before it, and a continuous circulation is produced; the whole length of pipe becomes heated by degrees, and gives off this heat to the rooms. The boiler may be of ordinary form, or it may be (as in Mr. Perkins's system) merely a part of the pipe itself coiled up into a compact mass and placed in a furnace. It is said that the first building warmed with hot water was a greenhouse at Newcastle, in 1716; but that the first successful application on a large scale was at a hatching-room—a chicken factory, as it may be termed—in 1776. Since then the method has come largely into use. Sometimes pipes are conducted into the rooms to be heated, as at the British Museum, and there coiled up under handsome pedestals; sometimes a current of air is heated by being made to pass over the surface of a vessel containing hot water, as at the new Houses of Parliament, and then made to circulate by a draught caused by artificial means. Mr. Pannell's 'Retort Calorifère' is a recent contrivance for applying the hot-water method to conservatories.

Perhaps the greatest 'curiosity' in modern warming, connected with ventilation, is the new Palace of the Legislature. The world is staggered at being officially told that 150,000*l.* has been spent in the arrangements for warming, lighting, and ventilating that structure; and is little less staggered to find that the light offends one, the warm air another, the cold air a third, the entire ventilation a fourth. But, in truth, there have been too many lawgivers on the subject; four distinct authorities have given independent orders; two distinct parties have attempted to carry out these orders; and all the six have been playing at cross-purposes in consequence of this divided responsibility. No one system has had a fair trial; each of many systems has been allowed just strength enough to injure the others, but not enough to show its own excellence. If we must blame, let us award the blame to both Houses of Parliament and all the departments of the Government, leaving them to share it among them; the systems themselves, of warming and ventilation, ought not to be judged by any evidence which this expensively-ludicrous state of matters affords.

## Candle-light: its Production and its Varieties.

Let us now leave the region of *Fire*, and take a similar glance at that of *Light*.

Nations have not been wanting in variety in their modes of producing artificial light. The animal, the vegetable, and the mineral kingdoms have all been brought into requisition with this view. A splint of resinous wood has been the candle of many a nation, and is so at the present time in many parts of the Hebrides and of Ireland. The torch is a somewhat more elaborate agent; it was probably at first a staff of wood coated with resin or pitch; and such torches are known to have been used by the Greeks and Romans. The substitution of a rope of hemp for the piece of wood formed

the next stage; and thus the real torch or link was produced. The inflammable nature of all kinds of oil would naturally suggest their use for producing light; hence would arise the capturing of fish and animals, or the gathering of vegetable substances which yield oil; and hence, too, the construction of lamps and candelabra to contain this liquid. Then, when it was known (and it must have been known from the earliest times) that the solid fat of animals possesses the light-giving quality, a little ingenuity would suggest the construction of some sort of candle, in which a porous wick might be made to divide the melting fat or tallow into numberless little streams. In a further stage, it would be found that spirits and bitumens, wax and spermaceti, and many other substances, were inflammable; and contrivances would suggest themselves by which light might hence be obtained. Then, when coal became a common fuel, the brilliant little jets which occasionally dart out from it would induce an inquiry how such a source of illumination might be available; but it required the boldness of the nineteenth century to give a decisive answer to such a question. Next, as the electric spark is intensely brilliant, practical men would ponder on the possibility of converting it into a useful source of light; and we see in our own day how this possibility is being tested. Nay, even water itself is now narrowly watched, to see whether the hydrogen, which forms one of its constituents, may be liberated and made to render up its light-giving power.

It is not every one who understands the bit of philosophy involved in the burning of a candle. We may readily suppose—and the supposition is not a *very* absurd one—that the wick is intended to burn and to give light. Such, however, is not the case. The parallel, or nearly parallel, fibres of the wick form the walls of numerous minute tubes, up through which any liquid will ascend by the power of what is called 'capillary attraction;' and it is in this minutely-divided state that oil or melted tallow is best fitted for combustion. The heat of the candle melts the upper part of the tallow, which then in a liquid state ascends the little tubes of the wick, and is there burned; it is true that the wick is burned also; but this is not a necessary condition of the arrangement; the candle would give forth its light even if the wick were formed of an incombustible material.

How a candle is made, and from what materials, are matters fully described in works readily available. That the cotton threads are ranged parallel for wicks; that the wicks are slightly twisted; that they are dipped into a vat of steaming melted tallow; that ingenious mechanism is employed to aid the dipping; that some candles are cast in moulds instead of being dipped into vats—are facts pretty generally known. But the extent to which we are dependent on foreign countries for this tallow is greater than would be generally supposed. In 1850 this quantity was considerably beyond 100,000,000 lbs., a great portion of which came from Russia. Although we are a beef-eating people, our cattle do not furnish us with a sufficiency of tallow for candle and soap-making purposes; and we have to look to other countries in which the richness of the meat is not so much regarded as the quantity of the fat or tallow. The fat of all animals which is solid at the ordinary temperature of our climate is fitted for making candles; and it is for commercial rather than chemical reasons that the fat of oxen is more largely used by us than that of any other animal. The tallow-melting establishments of Russia are vast in size and most inodorous in character.

Candle-making (it is proper here to state) has now become quite a notable

example of factory operations, involving engineering and manufacturing chemistry on a very instructive scale. Among many large establishments there is one at Vauxhall where 'Price's Patent Candles' are made in almost inconceivable quantities. The candles are made of palm oil and cocoa-nut oil, of which many thousand tons per annum are now employed. This modern substitution of vegetable fat for animal fat is remarkable; it is bringing central Africa into intimate commercial relations with England; and many thoughtful persons are of opinion that it will do more than squadrons and treaties in suppressing the slave-trade. The palm oil is liquid in Africa, but it assumes a solid state in the colder climate of England. The casks containing it have steam forced into them, by which the oil is melted and made to flow out; and the oil is then purified and bleached to various degrees of whiteness, according to the purpose to which it is to be applied. The whitened cakes of palm oil are cut into slices by a machine; the slices are deposited on mats of cocoa-nut fibre; the mats are piled in heaps, with iron plates between them; the heaps are placed in hydraulic presses, where intense pressure brings the palm oil to the state of dry thin cakes. After a little more purification the palm oil is fitted for melting previous to the making of candles. They may be 'mould candles,' or 'patent Albert's,' or 'Child's night lights,' or 'Price's night lights;' but in all these cases there is now a remarkable tendency to employ machinery in the formation—some of it of a most ingenious description. It is to the French chemists that we owe much of the improvement recently made in candles; their separation of *stearine* or stearic acid from tallow has led to the production of candles which give a much purer and more brilliant light, and are much less offensive to the smell and the touch, than the old-fashioned tallow candles—without any notable increase in price.

Our manufacturers now exhibit to us specimens of bleached wax, of white and coloured wax candles, of white and coloured sperm candles, of stearine candles, of candles from mixed materials, and of wax and composite night lights. Some show their skill in making wax and composition candles with plaited wicks. A Durham manufacturer produces his "marbled tallow candles, which burn without snuffing, and emit an agreeable perfume during combustion." A clergyman has displayed his ingenuity in producing an 'acolyte,' a learned name for a little piece of mechanism to be put on the top of a lighted candle, to prevent it from 'guttering.'

In the mediæval revivals of the present day, 'mediæval candles' are not forgotten. They are intended for use in Catholic churches; for many generations in England they have generally been large but plain candles; but within a recent period they have been made in imitation of those which were in fashion in the middle ages, and which were made to embody a certain degree of symbolism. The *paschal candle*, used from Easter to Whitsuntide, is painted round the lower part with emblems and devices belonging to that period of the church year. The *lumen Christi*, to a certain extent emblematic of the Trinity, consists of three equal candles twisted around each other. Many other kinds have a definite meaning attached to them, either as altar-candles or procession-candles; and some of them, richly painted and gilt, show how much attention was paid to this matter in former times, and, perhaps, is likely to be paid again.

It would be unjust not to mention specially that ingenious creation of our day—the Palmer's candle. Anything more tidy and economical and self-adjusting can hardly be imagined. The wick is dexterously twisted round its own centre, in such manner that the top may turn outwards, and there catch

oxygen enough to consume away without need of snuffing. The snuffer-makers have no cause to bless Mr. Palmer; but the snuffer-users are certainly benefited. As to the candles themselves, they may be made of palm oil, or of tallow, or of stearine; the action of the self-snuffing wick is independent of the kind of fat employed. The candlestick employed is part and parcel of the apparatus; for by its means the flame of the candle is maintained at a uniform height from the table—a desideratum which readers and workers well know how to value.

## Lamp-light: the Combustible and the Apparatus.

Our lamps and their philosophy lead us into a very different commercial region from that with which candles have to do. In a *chemical* sense the difference is not great; for tallow and oil have a strong family resemblance. That one is solid in an English climate and the other liquid, is a chief point of difference; this is instructively shown in relation to palm oil, which is a liquid when it leaves Africa, but a solid when it reaches England.

Lamp oil, in this country, is still confined chiefly to that of the whale. There is a little obtained from seals and other animals, a little from olives and other plants, a little from camphine and other spirits—but our liquid fuel is for the most part whale oil. Nevertheless this oil has now so many rivals, and the whales (in the Greenland Seas at any rate) show so little disposition to be quietly captured, that the whale-fishery has become more precarious than at the beginning of the century.

What a strange and eventful occupation is this fishery! The ocean monsters who are the objects of it are frequently sixty feet long, forty in circumference, and weigh seventy tons—nearly equal to two hundred oxen; there are some whales even more than a hundred feet in length; and the open jaw would contain a ship's jolly-boat full of men. Such are the opponents with whom the whalers venture to grapple; and how do they effect this? A ship of three or four hundred tons leaves Hull, or Peterhead, or some other port (we may confine these few brief lines to the Greenland fishing by British whalers); it finishes its ballasting and laying in of stores at Shetland by the end of March, and reaches the icy seas around Greenland towards the end of May. Manned with a crew of forty or fifty men, and carrying six or seven strong and well-appointed boats, it roams about the seas till September or October, keeping a sharp look out for whales, and exposed repeatedly to imminent perils. When a whale is seen lying unconscious of danger in the water, the ship approaches to a certain distance, and puts forth its boats laden with men, who approach the floating leviathan. With harpoons and lances the animal is pierced, and with coils of rope he is allowed to expend his rage in diving deep into the flood. Modern ingenuity has supplied the whaler with a harpoon of more pretensions than the old familiar implement; it is Mr. Hodges's 'Patent Silent Harpoon Projector'—a harpoon, in fact, fired off by a gun. If the whale does not kill the men (which occasionally happens) the men generally succeed in killing the whale, and hauling him up to the side of the ship. Then commences the cutting up of the huge monster. The oil, as most readers are aware, is obtained from the *blubber* of the animal; this is really its fat, which forms a yellowish-white mass immediately under the skin, from eight to twenty inches in thickness. Men descend upon the floating carcase with well-spiked shoes upon their feet, cut off the blubber in large pieces, and hand these up to other men upon deck, by whom

it is cut up into smaller pieces, and then packed in the hold. The days were when the blubber was boiled in temporary establishments on the Greenland coast, and the oil alone brought home; and there have also been arrangements for boiling it on ship-board; but both methods are now abandoned. When the whalers are at leisure, they remove the blubber from the hold, cut it into small pieces, remove the skin and impurities, and pack the rest in casks. There may, on an average, be thirty tons of blubber from a full-grown whale; and from this is obtained above twenty tons of oil. When the whalers have tried their fortune throughout the summer months, and secured as many casks of blubber from as many whales as they can, they seek their way homewards; they land their cargo (say) at Hull, where, at the northern outskirts of the town, are establishments for boiling down the blubber and extracting the oil therefrom, to be used hereafter as lamp-oil.

There is nothing new in all these details; indeed, the whale fishery, from its very nature, does not admit of much variety in management. The changes are local and commercial, rather than technical. One change is that Scottish ports are getting ahead of English in respect to whaling ships; another change is that the North Atlantic is becoming yearly more and more bereft of whales, to the manifest loss of the whalers who voyage thither; a third is that the South Pacific, especially under the energetic management of the Messrs. Enderby, is becoming an important scene for our fisheries; while the North Pacific is with yet more energy crossed and recrossed by the American whalers.

The vegetable oils are procured much more easily; with less danger, less dirt, less uncertainty—whether at a less saleable price is a question for actual commerce to answer. Olive-oil, nut-oil, linseed-oil, hempseed-oil, rape-oil—all are procured by pressure of the vegetable substances which give them name.

How these various oils are employed to yield artificial light, our lamp-makers show most ingeniously. The old table-lamps and shop-lamps of our grandfathers' days gave a smoky and yellow light; then came Argand, who, by dexterously giving breathing room to the flame by means of a hollow wick, produced a less smoky and a less yellow light; and in more recent days came the multitude of contrivances by which air—and sometimes pure oxygen—is admitted to the flame. Many modern lamps, to which very high-sounding names are given, are simply oil-lamps, with an improved adjustment for the supply of the respiratory agent.

Chemistry and mechanism have certainly not been forgotten in the construction of modern lamps; it is indeed somewhat bewildering to read of the numerous novelties which appeal to public favour in this direction. At one time we are called upon to admire the *Soho* lamp, which is adapted for burning tallow or fat instead of oil. At another, our attention is directed to the *Carcel* lamp, named after a French lamp-maker; the oil is raised through tubes by clock-work, so as to overflow at the bottom of the wick, and thus keep it saturated. Then there are the *Hot-oil* lamp, in which the oil is heated between two concentric tubes near the flame; the *Meteor* lamp, which burns rape-oil; the *Solar* lamp, which burns seal-oil, and in which three distinct currents of air are ingeniously brought to bear upon the flame; the *Camphine* lamp (the members of which family rejoice in the names of the 'Vesta,' the 'Imperial,' the 'Victoria,' the 'Gem,' the 'Paragon,' 'Diamond,' &c.), in which the liquid employed is camphine, procured by distillation from common American turpentine; the *Benzole* lamp, the light of which is yielded by a hydrocarbon called benzole, obtained by distillation from coal-tar; the *Bude*-light, the ex-

cellence of which depends on the mode of admitting air to an ordinary oil or gas flame—and we might extend this list much further.

If we look around us, in our shops and bazaars and exhibitions, we see that, whatever may be said in respect to correct taste, the lamps of the present day are especially splendid and ambitious. Every new kind of oil or spirit or camphine, every new mode of applying solid tallow to a lamp-form apparatus, every suggested method of supplying air or gas to feed the combustion—has been made a foundation for one or other of many glittering kinds of adornments. Many of these attractive articles are, however, very complex and troublesome, and it has been quaintly observed, "a lamp which requires as much looking after, morning and evening, as a baby, is a luxury which those only who can keep a nursery-maid for it can properly enjoy." The telegraph lamps, the railway lamps, the lighthouse lamps, the carriage lamps, the ship lamps, the miners' lamps—all have certain mechanical adjustments which fit them for their peculiar purposes; but we are now speaking of the decorative treatment of domestic lamps. These, whether called Argand or Carcel or camphine, or by any other name, do certainly now display much variety of adornment. White metal work, with dead-white glass, brass-work and coloured glass, bronze-work with medallion decorations, porcelain relieved with enamel painting—all are presented in most varied array. And the forms are not less diverse; sometimes the shaft imitates the stem of a plant, at others the ancient tripod, while in other instances an attempt is made to devise new and graceful forms. Messrs. Messenger, of Birmingham, who take a leading position in lamp-making and brass-work generally, are said to have had the aid of Flaxman and Chantrey, in throwing classic beauty into the forms adopted by them. And the glass globes and shades which environ the flame: how varied they are—cup-shaped, bell-shaped, tulip-shaped, lotus-shaped, ogive-shaped, oval-shaped—all are adopted.

The lamps now used for lighthouses are highly ingenious and beautiful. In the first place it is necessary to distinguish between two *systems*—the *catoptric* and the *dioptric*—the former depending on the reflection of light from a mirror, and the latter on the transmission of light through a lens. If a large lamp were placed on the top of a lighthouse, with glass roof and windows all around it, the light would shine in every direction, losing its intensity by being so much diffused; but by the use either of mirrors or of lenses, all the light is concentrated to one definite direction: its energy is increased by being circumscribed in range. In the catoptric system, numerous concave reflectors are placed at definite angles round a central lamp; they are of silvered copper, and are kept exquisitely bright; and they all contrive to reflect the rays out seaward, without allowing any to waste their power landward. The dioptric system involves the use of powerful convex lenses, through which the rays are focalised in a definite direction. If very large, these lenses would be difficult to make and costly to purchase; but it has been shown by Brewster and Fresnel, that a compound lens may be built up of a number of pieces, provided the curvatures are well adjusted.

In relation to this subject, we may here remark that our lighthouses and our Ordnance survey-stations so far resemble each other, that each must throw out a strong gleam of light to a great distance. Around our thousands of miles of coast—where the annual wrecks are from seven to eight hundred, and the property lost amounts to millions sterling—the lighthouses have passed through many stages of efficiency. First there was the large coal-fire used on the summits of open buildings; then the old-fashioned oil lamps, or some-

times wax candles, with a looking-glass reflector behind; then the more brightly-burning Argand lamp, with concave metallic reflectors behind; then the convex lens, to focalise the rays by transmission; and then the lens built up piecemeal, on the plan of Brewster and Fresnel, so that the light may appear almost as one vast luminous pillar.

The survey lights have not been less varied. The three angles of the enormous triangles by which a topographical survey is primarily conducted, sometimes eighty or a hundred miles asunder, must be visible one from another; but how to produce this visibility? In the earlier surveys, where such daring distances were not attempted, a signal light was in some cases obtained by reflecting the light of the sun from a well-adjusted surface of polished tin; or by Bengal lights being fired at night; or by a powerful Argand lamp being placed behind a lens or before a parabolic reflector; but Lieutenant Drummond, during the progress of the Irish survey, made a happy suggestion which eclipsed in efficiency all others. In what is called the *Drummond* or *Lime light*, a small ball of lime is exposed to the action of a spirit-flame fed by pure oxygen gas; the flame, in a highly vivid state, heats the lime to an intense degree, and in this heated state it emits a light of surprising brilliancy, far exceeding that of any flame yet seen. So beautifully was Drummond's apparatus constructed, that the lamp fed itself with spirit and with oxygen, supplied itself with balls of lime as each one slowly wasted, and reflected its surpassing light from an exquisitely-polished parabolic surface of silvered copper. It was not merely figuratively but literally true, that a piece of lime, not bigger than a boy's marble, emitted a light at Londonderry which was visible at Belfast—a distance in a direct line of nearly seventy miles! On a later occasion Colonel Colby made a lime-light signal visible from Antrim in Ireland to Ben Lomond in Scotland, a straight-line distance of ninety-five miles.

## Gas-light: Half a Century's History.

The gas-lighting system now calls for a little notice—that system which the present century has seen to start into existence, to put forth modest pretensions, to struggle against commercial and social and practical obstacles, to conquer these obstacles one by one, to spread from the rich to the poor districts and from town into country, to ramify beneath our feet almost as extensively as water-pipes, and to extend to most continental countries.

It is difficult to appreciate fully the advantages of any notable invention or discovery, unless we bring the imagination to bear upon the state of things which preceded its introduction. How little, for example, can the present generation do justice to the grand social improvement now under notice! We can tell what it *is*; but only those whose memory extends back to the beginning of the present century can compare the present with that which preceded it. The oil lamps were few and defective; the streets were but partially lighted; the turnpike roads were left almost in darkness; the shops were insufficiently illumined; much daily trouble was given to all by whom lamps were used; and the oil being dependent in quantity on the success of the whale-fishers, was subject to frequent variation in price.

But it may be said, and said justly, that the lamp system which preceded gas was a great improvement on the earlier practice. The public streets owe much to later ages in respect to lighting; for in early times perambulators at night had no light but that of the flambeaux which were carried before them.

Paris was the first modern city which was lighted, and this was not till the sixteenth century; the lights were not lamps but were *fallots*, vessels filled with pitch, resin, and other combustibles. These stationary lights were some years afterwards superseded by lanterns; and about the middle of the last century glass lamps began to be used, suspended over the middle of the streets by cords. London was somewhat behindhand in these matters; for until about 1736 few lights were used in the streets except those which the citizens hung out in front of their houses; but in that year five thousand glass lamps were set up by the corporation. In many of the cities of the Continent—Amsterdam, Hamburgh, Venice, Madrid, &c.—the streets were first lighted in the seventeenth century. Rome had no street lights until the end of the last century, when Pope Sixtus VI. adopted the singular expedient of ordering the number of lights before the images of saints to be increased, as a means of lessening the gloom of the streets. In Vienna, until 1780, the inhabitants had to take down the lamps from before their doors in the morning, take them to the lamp-office to be filled with oil, and light them in the evening on a signal given by the public fire-bell—a clumsy method this, which was obviated by the establishment of a body of lamplighters.

Without departing from our own country, we have abundant evidence of the characteristics of the streets of a busy city before the introduction of gas-lighting. There was the London marching watch of Henry the Eighth's time, with the cressets or iron frames filled with burning pitchy ropes; there was the time of peril and danger when this watch was abolished on account of the expense to the citizens; there was the establishment of the standing watch or watchmen, with lanterns instead of cressets; there were the three centuries of contest between the corporation and the citizens as to whether the lighting should be individual or corporate; there were the robberies and murders and other deeds of violence in dark alleys, because only those who paid ten pounds a year rental were required to light the front of their houses; there were the flambeaux and link-boys of Hogarth's days, and the lamplighters of George the Third's time—all this, and much more, illustrative of the lighting (or non-lighting) of the metropolis in past days, is pleasantly depicted in Mr. Knight's 'London.'

But the age of gas approached. It was in 1792 that Mr. Murdoch showed that gas-lighting was practicable; and five years afterwards he applied it on a large scale at the Soho Factory at Birmingham. It was in 1803 that Mr. Winsor lighted the Lyceum Theatre with gas, and in the next following year that the first Manchester factory was so lighted. Its fame and its use spread to Halifax and to other northern towns; but the metropolis received the new-comer distrustfully. It was in vain for Mr. Winsor to announce a 'National Light and Heat Company,' and to promise the shareholders an unheard-of dividend on their capital; the gas hitherto made had not been pure, its odour was offensive, and the Londoners would have none of it. The difficulties, however, were overcome on the one hand, and the prejudices on the other; and by the year 1823 there were upwards of a hundred miles of gas-pipes running beneath the streets of the great metropolis.

How the gas system has progressed in the last thirty years is most striking. Mr. Rutter has stated that, in 1848, there were six million tons of coal consumed annually in England for gas-making alone; that one-twelfth of this, or half a million tons, was so used in London; and that the main pipes which conveyed this gas to the houses of London were fifteen hundred miles in length.

And it was not in London alone that this astonishing advance was observable; there were nearly six hundred proprietary gas-works in England and Wales in that year, and nearly two hundred in Scotland and Ireland; and at these several works there were many thousand million cubic feet of gas produced annually. In the four subsequent years the advance has been very rapid; and a ton of coals is now made to yield more gas than by the earlier processes.

What our great gas-works are, nearly every one now knows. The retorts for containing the coal, the ovens for heating the retorts, the vessels through which the gas passes to be purified by chemical means, the enormous gasometers or reservoirs in which it is stored for use, and the wonderful system of pipes by which it is conveyed to our streets and houses, all are rendered tolerably familiar to us; and recent discussions have rendered them still more so, especially to the citizens of London.

The years 1850-51 witnessed a fierce gas agitation in the metropolis. The City of London Gas-light Company had, up to that time, supplied a large number of the citizens; but there having been many arguments to show that the price charged was unwarrantably high, a 'Great Central Gas Consumers' Company' was formed, professedly with a view of enabling the users to reap all the profit from the manufacture. The price, under the threatened competition, fell from 10*s.* to 7*s.*, 6*s.*, and then 4*s.* per thousand cubic feet. The new company was formed; and in the autumn of that year the streets of the City were brought into an extraordinary condition, by the laying down of new pipes; and the 'gas agitation' became offensive alike to the eye, to the nostrils, and to good sense. Within six months after the commencement of operations, the new company supplied 4500 consumers, with about a million feet of gas per week. After many struggles, and much waste of property, the two companies combined; but in order to secure to the gas consumers some instalment of advantage from the conflict, it was agreed that the gas should be charged as low as 4*s.*; and that if the united company should ever be lucky enough to realise a dividend of 10 per cent., any surplus profit should be applied to a further lessening of the price of gas. It is not often that the public make so good a bargain in the patching-up of companies' quarrels.

We stated in a recent paragraph that the arrangements and processes of gas-works are pretty generally known; but it is not less necessary to bear in mind that improvements are constantly being introduced in one or other of the various operations or the mechanism by which they are conducted. At the new works of the 'Gas Consumers' Company,' for instance, many novelties are introduced; and indeed it is these novelties which enable the new companies to undersell the old, by producing a given amount of gas with a less amount of sunk capital. So in the new 'Western Gas-light Company,' whose works have been recently established at Kensall Green. Here the operations are conducted on a system patented by Mr. Palmer. Cannel coal is now known to yield a larger quantity and a purer quality of gas than ordinary coal; and Mr. Palmer hence adopts it. There is a polygonal building of twelve sides, 166 feet in diameter, and containing 360 retorts; the gas made in these retorts is purified by passing through water, then through a rotating tank, then through a refrigerating apparatus, then through a shower of liquid ammonia drops, then through an atmosphere of steam, and then through lime. All this may appear very complex; but in truth the gas from coal contains a large number of foreign substances, each of which requires its own particular process for removal. The principal gasometer or gas-holder at

these works is of vast magnitude: it is 185 feet in diameter, by 25 feet deep; it weighs 150 tons, and will contain more than 350,000 cubic feet of gas.

One of the singular novelties of recent times arose out of the backwardness of mechanical art in Mexico. The apparatus for a new gas-work was sent out from England to Mexico; but it was feared that there were no workmen in that city who could efficiently put together the pieces of metal for large gasometers. Mr. Hancock, therefore, was invited to apply the aid of india rubber to this purpose; he made canvas bags twelve feet in diameter by fifteen high; the canvas was saturated with india rubber, and the bags were rendered cylindrical by iron hoops; and thus each bag became a gasometer.

Mr. Leslie's gas burners are coming largely into use in public establishments. At the General Post Office, at some of the government offices, at many banking houses, and at the Thames Tunnel, they are now employed. The gas flows through a circle of small tubes, each tube surrounded by the atmospheric current at the point where the gas issues and is ignited; from which follows a more complete combustion of the gas, and a purer and more brilliant light, than by the ordinary arrangement. This result is further carried out by the adoption of lamp-glasses, the shape and capacity of which vary according to the quantity of gas to be consumed in a given time. There is here something like the precision of chemical adaptation. Mr. Leslie has also contrived an apparatus for purifying gas before its combustion. Notwithstanding the numerous processes to which the gas is subjected at the works, it always contains a little sulphur and ammonia; and these substances not only vitiate the air, but they lessen the brilliancy of the light produced. Mr. Leslie's apparatus consists of an enclosed chest, kept in the house of the consumer; through it all the gas must pass on its way to the burners, and in its passage it comes in contact with lime and other chemical substances, which deprive it of the sulphur and ammonia. It is only in large establishments where such a purifying apparatus would pay itself; but where the jets are reckoned by hundreds rather than by tens, the combined use of the purifier and the new burner is said to be productive of a very remarkable saving. Dr. Playfair has recently drawn the attention of the Government to the excellent results observable at the General Post Office. In respect to the ordinary burners, nothing can be more varied than the forms which they are now made to assume; the cheapness of gas and the cheapness of glass have led to an almost infinite variety in our shop-windows and public buildings—not always tasteful, it is true; but yet much grace and beauty are occasionally shown in the gas-light arrangements.

The philosophy of gas and the philosophy of cooking are now brought into most useful companionship. Let us take as an example the gas-cooking apparatus which the good folks of Liverpool are said to patronise. Around the 'dripping-pan' is a gas-pipe, which supplies numerous little jets to heat the whole apparatus; the meat to be roasted is hung over the centre of the place bounded by the magic circle of gas; and the meat to be baked is placed in a closed compartment, also over the heating agent. At the top of the stove are eight or ten spiral burners, sunk a little way below the surface; and here the culinary operations of broiling, frying, boiling, steaming, stewing, &c., are conducted. All the compartments are furnished with dampers to regulate the heat, and separate doors in front give access to each compartment. If, as the inventors tell us, "sixty mutton chops can be cooked at an outlay of only twopence for gas," the apparatus must indeed be a pattern of

economy. Other gas-cooking stoves are now putting forth their claims to public favour; one, we are told, can "cook a pair of chickens, 4 lbs. of beef, potatoes (both baked and boiled) and boil a vessel of water, with less than two-pennyworth of gas." M. Soyer, who provided a dinner on a large scale, and at a short notice, for the Agricultural Society at their Exeter meeting, is said to have done wonders with an extemporaneous gas-cooking apparatus; he cooked 560 lbs. of meat in five hours, with a consumption of 750 cubic feet of gas; according to the modern London tariff the gas would have cost only 3*s.*; but the Exeter arrangement was of course not governed in relation to any saving of a few shillings in fuel. In most of these gas stoves the heating arrangements are of two kinds; in one the lighted jets are placed beneath the metallic bottom of a boiler, a saucepan, or other cooking vessel, or an oven; in the other the lighted jets are ranged in a circle within and above which a joint is suspended for roasting. If well managed, no gas odour vitiates the meat.

On a busy Saturday night, when many of the streets are thronged with retail dealers in all kinds of commodities—edible and culinary—there may often be seen stalls or stands lighted up with more than ordinary brilliancy, attracting no small attention thereby. The form of lamp or light is ambiguous: it may be from gas, or it may be from oil—few can tell at the first glance which is its real character. It is in fact something between the two. The principle acted on is that of Holliday's 'Self-generating Gas-lamp,' in which the lamp makes its own gas while burning. The combustible employed is naphtha. There is a reservoir of this liquid, into which a wick dips; the naphtha ascends by capillary attraction; when it arrives near the burner, the extreme volatility of the naphtha causes it to vaporise by the heat of the lamp; and this naphthalic vapour, mingling with a small portion of atmospheric air, forms a gas well fitted for lighting, when ignited at small jets. The arrangement of the apparatus admits of various modifications; but the principle of action depends on the formation of vapour of naphtha, by the heat of the lamp itself.

Invention has been busy trying to produce gas-light for public purposes out of other substances than coal. One scheme is for *hydrocarbon* or *water-resin* gas, in which, by complicated means, water is decomposed in one vessel and resin in another, and the resulting gases made to combine for producing light. But chemists have shown that the quantity of gas produced is not adequate to the cost of the resin consumed; and such is found to be the case in respect to many other proposed schemes.

Of the *Electric Light*, a little has been said in another part of this work.

# WOOL AND SILK, FUR AND FEATHERS.

THE lower animals not only give us their flesh for our food, but their clothing becomes our clothing. We are proud enough when we compare ourselves with them; but not too proud to wear the same garments, or garments made from the same materials. The sheep gives us our coats and a multitude of materials for dress, including some of the most delicate for ladies' wear; the goat supplies us with the mohair and the Cashmere which now enter so largely into dress; the llama gives us alpaca; the little silkworm gives up its egg-shaped house, its cocoon, to supply us with silk; the beaver and the sable, the savage bear and the lightsome squirrel, and numerous other animals, yield up their hairy coats to form our hats and our furriery; the birds give us their feathers, either for snug bed-clothing by night, or for personal adornment by day.

## WOOL:—BROADCLOTH AND FULLED MANUFACTURES.

One of the most instructive features in our wool trade, at present, is the substitution of colonial wool for German and Spanish wool. Our imports of Spanish wool, in the period between 1815 and 1849, fell from 7,000,000 lbs. to 100,000 lbs. annually; while that from Australia rose from 70,000 lbs. to 36,000,000 lbs. Of our total import in 1849 (77,000,000 lbs.), more than half came from British colonies; and each succeeding year presents yet more striking evidences in the same direction. For instance, the recent Board of Trade returns tell us that in 1851 we imported 81,000,000 lbs. of wool, of which the truly enormous quantity of 52,000,000 lbs. was from our own colonies. It is another remarkable feature, that the beautifully soft silky *alpaca* wool or hair (for it partakes somewhat of both) has now become such a favourite material for dress, that 2,000,000 lbs. were imported in 1851. The day has gone by when 'super Saxony' was a name really applicable to a piece of broadcloth; Australia has nearly displaced Saxony in our wool markets. Yet (so much for fashion) we are not told about 'super Australian' cloths; we wear the cloth without knowing or caring whether the wool from which it was made has been brought from our own colonies.

How much *English* wool is worked up with this continental and colonial wool, no one seems to know; but our parliamentary returns tell us that—be the quantity what it may—our woollen and worsted factories now number more than 2000, employing 160,000 persons, 2,500,000 spindles to spin the wool into yarn, and 45,000 power-looms to weave this yarn into cloth. This relates to factory operations alone; it touches not upon that vast system of cottage industry which so especially distinguishes the woollen trade, and renders the Yorkshire valleys alive with industrious workers.

There is a certain family likeness between the processes to which a bag of

wool is subjected in the course of manufacture, and those which apply more particularly to a bale of cotton; and yet there are differences which show that animal and vegetable filaments have each a particular range of qualities which require to be humoured in the manufacture.

Let the transformation be from a bag of wool to a piece of superfine broad cloth. First we see the wool tumbled out of its bag, and subjected to the disentangling action of a 'devil,' or 'teazer,' or 'willy,' the sharp teeth of which sever the locks of wool one from another. Next we trace it through a 'burring machine,' the rollers of which separate the clotted burs which would vitiate the quality of the cloth. Then comes into action the oddly-named 'scribbling machine,' by the sharp teeth of which the fibres are scribbled straight and parallel, and brought into a continuous roll. We see this soft roll of wool sucked into the funnel of a 'lap machine,' and quickly coiled round a tin frame or cylinder. Next we follow the progress of these coils, and find that several of them are transferred to the 'carding engine,' where the fibres are combined together, and carded out into a continuous sliver. By repetition of these drawings and cardings and combings, varying in number according to the kind of material employed, the wool is at length brought to the required loose thread-like state; and it is then spun into yarn by a 'mule-machine.' Arrived at length at the cloth region, we trace the woollen yarn through its successive stages. First there comes the weaving, which in the West of England is still effected chiefly by the hand-loom, but which in the West Riding is gradually coming within the domain of the power-loom. Then we trace the cloth to the 'beating stocks,' by which the grease and oil are beaten and washed out of the cloth; and to the 'fulling stocks,' by the incessant thumping of which the cloth is shortened, narrowed, thickened, and matted in that peculiar way which constitutes *felting*. The 'gig-mill,' with its attire of teazles or of wire teeth, then comes into use, for rubbing or scratching up the filaments of wool, to make a pile or nap; and the cloth, not being yet enough tantalised by these various ordeals, passes to the 'shearing machine,' to have the pile closely shaved down; and to the 'brushing machine,' to have the short and beautiful nap brushed uniformly in one direction; and to the 'pressing machine,' to give it that attractive and finished appearance which 'extra Saxony super' is expected to present.

In one and all of the above processes the machines employed have undergone, and are still undergoing, rapid changes and improvements. The machines of bygone years become obsolete; and even manufacturers living in the same district have each his own favourite patented machines. The same may be said, too, of the *worsted*, or *stuff*, or *hosiery* manufacture, in which long wool is employed. This wool does not *felt* or *full*, and requires a different train of processes, some of which employ very beautiful machinery.

It is not one of the least curious among our factory characteristics that two districts, widely separated, share the honour and the profit of our woollen manufactures—the West of England and the West Riding. The former produces principally fine cloth, which is mostly used at home; the latter produces all kinds, for the foreign as well as the home markets. The former retains to a great extent the domestic or hand-work system of old times; while the latter is every year adopting more largely the factory system. In the West of England district (Gloucester, Somerset, Wilts, and part of the adjacent counties), Trowbridge is a great centre for 'trouserings' and narrow goods; Frome for coloured woollens; Dorchester for kerseys and drab coatings; while Stroud, Melksham, Chippenham, Tiverton, and other towns, are

the centres of clustered villages in which broadcloths are made. If there be one town in England which takes the lead of all others in the finest cloth, whether scarlet for the officer or black for the civilian, perhaps it is Stroud. Why it is that the West Riding is adopting more rapidly than the West of England the system of factory labour, may perhaps be explained by the facts that coal is cheaper, that steam and water power are more readily obtainable, that an abundant working population is always at hand, that a complete network of railways exists, and that the two great shipping ports of Hull and Liverpool lie east and west of the 'clothing valleys.' There are no such industrious valleys as these in any other part of England, and there is no other great manufacturing district which presents so many picturesque spots; on the hill-sides and on the valley-bottoms the clothiers live in villages clustered together with a closeness which would astonish those who are familiar only with agricultural villages.

The variety of goods which come under the designation of woollen manufactures is (we may almost say) increasing every year. 'Broad cloth' and 'narrow cloth,' 'Clarendons' and 'Petershams,' 'cashmeres,' 'cashmerettes,' 'kerseys,' 'tweeds,' 'tartans,' 'linsey woolseys,' 'angolas,' 'vicugnas,' 'Venetians,' 'llamas,' 'Sardinians,' 'Himalayas,' 'moleskins,' 'doeskins,' 'beavers,' 'trouserings,' 'vestings,' 'coatings'—there is really no end to the names; for the manufacturers, not content with distinguishing names for particular materials and particular modes of manufacture, conjure up new names on any grounds or no grounds, for the charm of novelty. Many of the names, however, might be made significant of really curious novelties in the manufacture. Thus, there is a new 'bis-unique cloth,' of double thickness, the two surfaces having different patterns, so that the wearer may have either side outwards, at his pleasure. There is Mr. Barber's cloth, wholly made from beaver fur—soft, light, and warm—for winter garments. There is, as a third example, the comically-named Irish 'rumswizzle,' a very excellent brownish frieze made of undyed foreign wool.

Nothing in our economical age is, perhaps, a greater industrial 'curiosity' than the *shoddy*, made at some of the Yorkshire mills. The old woollen rags —the last organic remains of coats and trousers—used to be employed for various trifling purposes; but they have now risen in dignity: they have become the elements out of which *new* coats and trousers will spring. There is here a kind of metempsychosis of garments, which the ancients knew nothing about. Dewsbury draws to itself woollen rags from all parts of Europe; coarse, fine, little worn, much worn, white, coloured, clean, dirty— all are welcome; they may be so good as to command 50*l*. per ton, or so bad as to be worth less than that number of shillings: they may be clean from Scotland or from Denmark, or dirty from Ireland or Italy—all are grist to the Dewsbury mills. Here they are 'devilled,' or torn to tatters by the sharp spikes of rapidly-revolving machines; the 'devil's dust' rises in stinking clouds, and befouls the whole town in its descent; and the women, while sorting the rags, and the men, while feeding the 'devils' with rags, muffle their mouths to ward off the choking effects of the unsavoury dust. Taken altogether, this is, perhaps, the vilest stage in any department of our textile manufactures. Some of the 'shoddy,' worked up into poor flimsy cloth, is exported to South America for slave-clothing; but more generally it is mixed up with a greater or less proportion of new wool, and then spun into yarn for coarse goods. If the history of a slop-shop coat could be told, we might perchance find that it had had a previous state of existence; that after having

gone through a term of service, and borne its share of rough weather and rough usage, it had been be-devilled at Dewsbury, and the shoddy mixed with new wool to form the sleek, glossy, but treacherous material for a new coat. As the shoddy must necessarily be *very* short fibred, we have no right to expect strength in any cloth wherein it forms a part.

WOOL:—STUFFS, FLANNELS, BLANKETS, CASHMERES, ALPACAS.

Let us pass on, however, to another and not less remarkable section of the wool trade. Although the Yorkshire clothing-valleys are identified with the woollen-cloth manufacture, the West Riding generally cannot be understood without reference to the modern characteristics of the long-wool or unfelted wool manufacture. The *stuffs* or *mixed goods* of the West Riding have no parallel in any other country. In bygone times stuffs and such like worsted goods were as commonly worn by women as woollen cloths were by men; and Norwich, with some few other towns, were celebrated for their manufacture. But an astonishing change has come over this department of manufacture. By mixing alpaca and other fine wools with coarser varieties; by combining one or more of these with cotton or silk, or both; by increasing the richness of the dyes given to the yarn; by the employment of tasteful designers in producing patterns; and by the adoption of all available improvements in looms and weaving apparatus—the 'mixed goods' (as they are now called) have risen to a manufacture of great magnitude; one almost peculiar to England, and which at the present time almost rivals that of woollens in the West Riding. Bradford, Halifax, Huddersfield—each is the head-quarters of one particular branch of this new trade: in Bradford dress goods for ladies, in Huddersfield fancy waistcoatings, in Halifax furniture damasks. It is hardly possible to conceive the rapid rise of Bradford in this trade without comparing its present condition with that of half a century back. It was then a mere nothing, very little more than a village; whereas it is now one of the largest towns in the West Riding. Bradford shares with Brighton the reputation of having risen in population and wealth more rapidly than any other towns in England. True it is, that the Sanitary Commission gave it a sadly dirty character eight or nine years ago; but it has mended its manners and washed its face since. Halifax and Bradford are near neighbours; but they present many points of contrast. Halifax is a very old town, Bradford has sprung into notice recently; Halifax has steep hills and picturesque houses and gables, Bradford has nothing picturesque; Halifax manufactures an immense variety of goods, Bradford confines itself more to plain stuffs; Halifax only buys wool for itself and a small surrounding district, Bradford buys and sells for an immense range of country, and is more a prey to speculative fevers and agues.

We may say of these mixed or long-wool goods, as we did of the woollen or short-wool goods, that their names are almost interminably bewildering. We have alpacas, mohairs, mousselines de laine, mousselines de soie, merinos, Coburgs, Orleans, Henriettas, poplins, paramattas, princettes, quiltings, trouserings, cashmeres, damasks, moreens, table-covers, and a host of others: some named according to the kind of wool employed, some according to the admixture of other fibres with the wool, some according to the mode of manufacture, others according to the purposes to which they are to be applied, and the rest according to any fanciful idea which the manufacturer hopes may assist his sale in the market. Greatly as these differ one from

another, they have these points of general resemblance—that they contain long wool instead of the short wool employed for broadcloth; that printing and pattern-weaving are much more largely attended to; and that there is (usually) no nap or pile on the finished goods. Some of the yarn for the finer goods is spun to a high degree of delicacy; thus, No. 160, in this department of manufacture, contains upwards of 50 miles of yarn in 1 lb. weight. If the reader can form a clear conception of the various degrees of fineness in the yarns, of the mixture of silk with wool in some of the yarns, of the occasional interlacing of silk or cotton yarns with those of wool, of the dyeing or printing (or both) of the yarns before weaving, of the production of elaborate patterns by the loom, and of the printing after the weaving—he will see how it is that, by combining any number of these sources of variety, the West Riding manufacturers can throw such endless diversity into their mixed fabrics. Belgium, France, Saxony, Prussia, Austria—all can equal the West Riding in broadcloths and other woollen goods; but none of them approach it in this more modern department of industry.

In Bradford alone there are said to be upwards of 15,000 men employed in wool-combing, preparatory to the spinning and weaving processes. This wool-combing is not, except in a few cases, a factory occupation; it is done at the homes of the combers, and is paid for as piece-work. To save rent and fire and candle, three or four of these men work together in one room, assisted by their wives and children in the easiest parts of the work, and doing the rest themselves.

Why should Rochdale make such millions of yards of flannel, and yet produce little else in woollen or worsteds? It is one of those peculiarities with which we are occasionally struck in the location of manufactures, a satisfactory cause for which it is difficult to assign. Rochdale is quite out of the woollen district of the West Riding; it is in Lancashire, among the cotton towns; and yet it produces flannels in enormous quantity—far greater than any other town in England. Indeed it is *the* market for flannels; the prices at Rochdale govern those elsewhere, and regulate large purchases. If we look at the trade reports given in the daily newspapers, and find that at a particular time flannels are 'looking up,' or 'go off briskly,' or 'hang heavily,' we shall find that the writer of the report has Rochdale in his mind as the centre of operations. Flannels are much more luxurious productions than they were in years gone by. We knew them ordinarily only as woollen or worsted goods; but modern ingenuity has devised flannel made of mingled wool and silk. Its inventors claim for it a superiority over ordinary flannels, in being "less irritating to the skin; it shrinks less in washing; the silk increases the strength and durability of the texture, and renders it less liable to tear." Such flannels have even been embroidered, and used for ladies' opera cloaks. Then we have choice 'Tibet' flannels, made from the finest wool; and flax flannels, in which flax, prepared on Claussen's process, is mixed with wool; and fancy-coloured flannels—pink, rose-colour, cherry, crimson, blue, orange, and other dainty tints. The philosophy of cheapness has also visited the flannel regions, for some of the low-priced flannels contain a portion, more or less, of cotton. There are striped flannels, and cricketers' flannels, and 'anti-rheumatic' flannels, and many other special and oddly-named kinds.

As it is with Rochdale and its flannels, so it is also with Dewsbury in respect to blankets; each is the central market for the commodity which is manufactured there to a larger extent than in any other town. It might appear that flannel

and blankets, so similar in many of their characteristics, would find a home in the same factories, or at least in the same town; but such is not the case —Dewsbury yields the palm to Rochdale in the one, but expects equal deference to be paid to itself in the other. The 'Yorkshire Directory,' which we may assume to be a trustworthy authority, gives us no less than a hundred and eighty 'blanket manufacturers' at Dewsbury; and as among these there are ten Ellises, six Crawshaws, six Seniors, and four or five repetitions of half a dozen other names, we see at once an indication of the old-fashioned West Riding custom, where one particular trade remains in the same family for generations.

It is an interesting feature in the modern history of the woollen manufacture, that the wool or rather hair of the Cashmere goat is becoming a favourite material in cloth of the better kind. Not that all the 'Cashmeres' of the shops are really Cashmeres; the *morale* of trade has not yet reached the point when things are called by their right names; and the beautiful Asiatic valley is quite innocent of the greater part of those products which rejoice in the name of 'Cashmeres.' Still the high-born and the wealthy occasionally purchase shawls which were really made in that region; and (what is more interesting to us) attempts are being made to naturalise in this country the animal which produces the beautiful filamentous material in question. The fleece of the Cashmere goat consists of two very different kinds of fibre—one of which is a fine, soft, pliable, rich wool, equal to the finest lamb's wool; while the other, called *kemp*, is a hard, stiff, coarse, rough kind of hair. The kemp may be used in the manufacture of coarse cloth; but every fibre must be removed before the fine wool can be employed in shawl-making; this removal is very difficult and tedious, and will be a bar to the spread of the manufacture unless some expeditious system to effect it can be devised. Prince Albert has some Cashmere goats at Windsor; and some few months before the Great Exhibition was opened he caused the fleeces of those goats to be forwarded to two manufacturing firms, one near Leeds and one near Halifax, there to be subjected to manufacturing processes. The separation of the fine wool from the kemp was a slow manipulative process, which many persons undertook voluntarily and pleasurably—for it will be something to talk of in future years, that the younger members of many respectable Yorkshire families assisted the Prince Consort to make a Cashmere shawl. Of course the expense which would attend such a mode of manufacture for ordinary sale would be quite disproportionate to the result obtained; but the Prince's praiseworthy object was answered by showing that the Cashmere goat *can* be reared in this country, and that the fleecy covering can be wrought into cloth. The articles produced from the wool in question consisted of a piece of white cloth, with silk warp and Cashmere weft, woven with a brocaded figure; a piece of similar character, but dyed; two shawls made wholly of the Cashmere wool; and a coarse piece of woollen cloth made from the kemp or hair.

As with the Cashmere goat, so with the *alpaca;* attempts are being, or have been, made to naturalise it in this country. The alpaca is one among many species of the llama, the wool of which is very beautiful. The first visit of these animals to Europe was an adventurous one. Thirty-six travelled across the whole breadth of South America, from Lima to Buenos Ayres, in 1808, and were there shipped to Europe as a present to the Empress Josephine. At Cadiz the poor animals were ill-treated by a rabble, and only a small number were ultimately preserved in Spain—they never reached Josephine. By degrees it was found that alpaca wool was longer, softer, more

pliant, and more lustrous than sheep's wool; and the manufacturers of Bradford began to import it for use. Her Majesty possesses one or two of these animals at Windsor; and some articles of dress were made from the alpaca wool in 1844—one was an apron, entirely of alpaca; another was a striped and figured dress, with silk warp, alpaca weft, and alternate silk and alpaca figures; a third was a plaid dress, woven with an intermixture of alpaca, silk, and worsted; while a fourth was a plain black dress, with cotton warp and alpaca weft. Many attempts have been made to establish the breed of the alpaca in this country, but hitherto the enterprise has not been commercially successful.

## Wool:—Carpets and Tapestry.

We must depart a little from our 'clothing materials' to take a glance at carpet curiosities and novelties.

Among the luxuries in which England indulges to a greater extent than her continental neighbours are *carpets.* The parquetry or inlaid flooring of the Continent is much superior to our own modern flooring, because it is intended to remain uncovered; while the slippery waxed floors of French mansions exhibit another phase of the same system. John Bull attaches a notion of chilliness to an uncarpeted floor; it has none of the 'comfort' which he so much loves. "We Englishmen," it has been said, 'have dainty feet; we must have velvet lawns, as smooth as satin and as springy as leather; and carpets—fleecy, soft, glossy, peachy carpets—as smooth and as springy as our lawns." Yet it was not always so; we were not in advance of other nations in this respect in bygone ages. It was not till the time of Charles II. that the apartments of the wealthy began, as a regular custom, to be carpeted; and any person now tolerably advanced in years may well recollect that oak floors, deal floors, sanded floors, sawdust floors, rushed floors, concrete floors, brick floors—were much more prevalent in his early youth than they now are, even in houses of similar character.

It is nevertheless remarkable that England, which uses so many carpets, was by no means one of the earliest nations which manufactured them. Turkey and Persia supplied the soft and costly carpets for our drawing and dining rooms; while Flanders and France furnished those in which artistic beauty of design became gradually developed. The first English attempts in the manufacture appear to have had relation to cheap rather than beautiful carpets; but the manufacture has made a vast stride within a recent period; and it is pretty generally agreed that in material, in colour, and in pattern, we are approaching nearly to a level with the most skilled of our continental neighbours.

The names given to carpets are singular; for they are mostly those of towns or countries, which give very little information concerning the texture and quality of the carpet itself. Persian, Turkey, Venetian, Tournay, French, Brussels, Axminster, Wilton, Kidderminster, Scotch—these are the names of the carpets with which we are most familiar. In all these towns and countries carpets are or have been manufactured; and doubtless each kind of carpet had originally some distinctive qualities which its name served to indicate; but there are now distinctions without differences, and differences which the names fail to point out. Tournay carpets, Axminster carpets, and Wilton carpets, are very nearly alike; Axminster now produces no carpets at all; not one of our modern Brussels carpets comes from Brussels;

Kidderminster no longer makes Kidderminster carpets, but has raised its attention to the better kinds, such as the Brussels; the Kidderminster carpets, which are *not* made at Kidderminster, are now made in the north of England and the west of Scotland, and constitute the bulk of our cheap carpeting—such are the anomalies in the designation of carpets. As an illustration, we may mention that the carpets for the new House of Commons, comprising many thousand yards, though made at Kidderminster, are 'Brussels' carpeting, so called.

There are two characteristic processes in making a carpet—one adopted in the more costly varieties, and the other for those of lesser cost and more extensive use. The former are very little other than specimens of needlework: or rather they resemble *tapestry*. There is a frame in which the foundation of the carpet is stretched, as for ladies' tambour or Berlin work; and into and between the meshes of this foundation are introduced little tufts and threads of worsted, so disposed in colour as to produce any desired pattern. A peculiar kind of knot fastens each little tuft; and the arrangement of the front surface, according as it is looped, or cut, or sheared, produces the various kinds of Brussels and Saxony and 'pile' and 'velvet' carpets. The other or cheaper kinds are produced rather by the ordinary process of weaving, in which a shuttle, or set of shuttles, throws in the coloured weft threads among the warp; peculiar adaptations of a double weft or a double warp being employed according to the particular kind to be produced. In Tapestry and in the real Turkey carpets the manufacture bears some resemblance to lace-making, inasmuch as the fabric or foundation of the carpet is made by the same slow and patient hand-processes as the decorative surface; or, at most, the warp threads are previously arranged, and all the rest worked in by hand.

In all these carpets each yarn or separate thread is dyed of one colour throughout, so that there must be as many separate yarns as colours in the carpet. Now one of the modern novelties in carpet-making is to apply to it a principle which produces beautiful results in cottons and silks, viz., *printing* the yarns before weaving, so that each single thread may have a parti-coloured pattern of its own. This pattern requires a very nice adjustment, so that when the various threads are interlaced each may show the right colour at the right spot. Some of Mr. Whytock's carpets, produced on this principle, are very remarkable.

Another novelty is Messrs. Templeton's *chenille* carpets—soft, beautiful, but costly. These are made in a singular way. The warp-threads are stretched out horizontally, as in a common loom; and the weft is thrown in by a shuttle; but this weft consists of chenille instead of mere yarn; and when the weaving is effected, the loose coloured threads of the chenille are combed up and made to appear at the surface, where they are cut and sheared to an exquisite state of velvety softness. The pattern is dyed in the chenille itself, nothing appearing at the surface of the carpet except the ends of the chenille fringe.

A later novelty, and one which seems likely to lessen the price of well-made carpets, is an application of the power-loom in weaving with the printing process in ornamenting. The yarn is subjected to no dyeing or printing whatever; it remains in the state of white worsted, and is in that state woven by the power-loom. Then, after the weaving, the white carpet is printed with rich colours, in such a way as to send the dye through the whole substance.

We mentioned in a late paragraph that the House of Commons is carpeted

with 'Brussels' made at Kidderminster; and it may here be stated that the House of Lords' library, and some of the other apartments of the new legislative palace, are carpeted with the more costly and luxurious 'velvet pile,' in which the foot sinks into a downy bed at each step. This is the true 'Wilton' carpet, which differs from 'Brussels' chiefly in having the loops at the surface cut in the manner of velvet, thereby forming a nap or pile. Most of our carpets are made of mingled worsted and linen—the latter hidden from sight by being placed at or near the back of the fabric. Cotton—that substitute for all the dearer kinds of textile fibres at the present day—has not yet been used much in carpets. A suggestion has been made, however, that such an application might not be at all unreasonable. Cotton carpets—stout, serviceable, and handsome—are made and used in India; they are generally striped, red and blue, or with three shades of blue; but sometimes they have figured patterns. Our cotton manufacturers can now produce very stout and durable goods; and we may yet see the day for cotton carpets. Let them, however, be *called* cotton, and not palmed off as being made of more costly materials; if known at all, let them be honestly known by their proper names.

The 'ladies' carpet,' which has acquired such notoriety in connection with the recent Exhibition, is noteworthy on many grounds. It is not a woven carpet, in the ordinary sense, but is really needlework, and was intended by the ladies partly as a specimen of the profitable employment of their leisure hours. Mr. Papworth sketched the original design, to be worked in Berlin wool. The carpet measures thirty feet by twenty; it was divided into a hundred and fifty squares measuring two feet each way, and each square was worked by one lady; the whole were then sewn together, and were, of course, so planned as to form part of the general pattern. In the pattern, besides geometrical and floral devices, there is an heraldic border so laid out as to contain the initials of all the lady executants. From an address, presented by the ladies to Her Majesty on the occasion of presentation, it appears that the gift was an afterthought. "It (the carpet) was commenced with a wish that their skill should be represented at the Industrial Exhibition of all Nations; but the opinions expressed of their work have so far exceeded their expectations, that they are led to trust it is not unworthy of your Majesty's favourable notice." The Irish ladies, too, produced *their* joint carpet; it was produced by a hundred and fifteen fair executants, and occupied six months in fabrication; it was worked in squares, thirteen in length and seven in width, and—unlike the English ladies' carpet—each square formed a distinct design in itself, though all aided to form one general and more comprehensive pattern; the subjects of the several squares were flowers, fruit, birds, and landscapes. Other examples of patience in carpet-making are not wanting. There is Agnes Grosmann's carpet, in which the story of the Finding of Moses is worked in with the needle; and Weygold's carpet, in which half a million stitches are devoted to the story of Boaz and Ruth—but all such specimens are merely individual 'curiosities;' they are of no commercial importance.

As tapestry is associated with the past rather than with modern inventions, we will say a few words respecting it only to show in what it differs from carpet-making and from ordinary weaving. What is *Gobelin* tapestry, and who was Gobelin, and where did he live? Many admirers of tapestry have had to ask these questions. Gobelin, then, was a French dyer, who resided in the Faubourg St. Marcel, at Paris, some two centuries and a half ago; he was succeeded by others who added carpet-making to dyeing, and these by

others who added tapestry-working; still the establishment continued to be called, as it has ever since been called, "the Gobelins." Louis XIV. made the Gobelins a royal establishment, which it has ever since remained—artistically advantageous, but commercially very costly to the nation. These tapestries are for the most part imitations of pictures, every line and colour of which are to be faithfully copied. Measured by actual surface, it is difficult to say whether tapestry or lace is the most tedious to produce; high-class lace is certainly more costly than any tapestry, but it is at the same time noteworthy, that a skilful tapestry weaver, doing his best at the best work, can only produce eight or nine square yards in a year; no wonder, then, that good tapestry commands so high a price. A manufacture of rich carpets, on the tapestry principle, was combined with the Gobelins establishment twenty or thirty years ago.

### Wool:—Hosiery, Knitting Machines.

The lace, mentioned in the above paragraph, we have nothing further to do with here, as it is for the most part a flaxen or a cotton material; but the hosiery claims a little attention, in respect to the wool which forms so notable an ingredient in it. Nay, although cotton stockings have to a large extent superseded worsted in England, and have tended to make Nottingham what it is, yet worsted was the material on which the first knitting frames were employed; worsted was the knitting material for the hosiery connected with the pleasant story of Lee the frame inventor; worsted is the only *home* produce which we have to apply to the hosiery manufacture; worsted is still the warmest and the strongest material employed for that purpose. Hosiery, however, is not simply confined to hose or stockings; gloves and all other garments which are made of the peculiar open elastic webbing made on the frame, now come under that common designation.

Worsted stockings are so completely associated with the Leicester district, that scarcely any are made in any other part of England—except the cottage knitting of the old housewife, which is independent of any such location. Nottingham is still the home of the cotton hosiery trade, Derby that of silk, and Leicester that of worsted. When machines or knitting frames first reached the Leicester district, about a century and a half ago, they were in great disfavour; the artificers worked at night, and secretly; and the produce was hawked about the country. Nearly a century afterwards a worsted spinning machine was invented; and this greatly increased the resources of the Leicester stockingers. There are at the present time, in Leicester and the neighbouring towns, not much fewer than twenty thousand frames or machines making worsted stockings, socks, gloves, mitts, shirts, drawers, waistcoats, jackets, caps, leggings, braces, 'polka jackets,' and such like articles—all bearing a family resemblance, in so far as they are produced by a kind of chain-stitch or loop, which imparts great elasticity. It is one among many odd proofs of the apparently capricious location of trades, that the material for nearly all our worsted gloves is made in Leicester and its neighbourhood, but many of the gloves themselves are cut out and sewed up in Worcester and its vicinity; Worcester does not make the web on which its thousands of glovers are employed. Men generally weave the stocking-web at Leicester, and women stitch it up into stockings; in the value of every pair, the weaving or knitting is about seven times that of the stitching.

Why the steam-engine is so little employed in the stocking-manufacture is

a social rather than a mechanical question. Large machines *are* occasionally worked, in large factories, for making stockings; but the wages of hand labour in this branch of industry are so low that manufacturers seem to view the factory system with indifference.

Improved hand-machines are, however, now employed.* The circular hosiery or knitting machine is certainly among the most beautiful contrivances of the age. It is said that the first idea of this machine was due to our French neighbours, who tried it in a rough way nearly a century ago. The late Sir M. I. Brunel, whose extraordinary mechanical genius manifested itself in so many directions, greatly improved the machine in question, and brought it over to England, where it was patented about forty years ago; but the machine worked slowly, and failed to establish itself. While, however, the English machinists and knitters allowed this matter to sleep, those of France and Belgium were steadily engaged in working out improvements either in principle or in detail; and we meet with the names of Touve, Gellett, Jacquin, Fouguet, Berthelot, and Claussen, in connection with these improvements. Chevalier Claussen, whose praiseworthy labours in respect to the flax manufacture have attracted so much attention, is one of the most successful of these improvers of the circular loom. His machine is now largely employed at Nottingham. The machine can manufacture all kinds of 'looped fabrics.' In the ordinary stocking frame the loops are made by an alternating motion; but in the circular loom, whether worked by hand or steam power, the motion of the web while being formed is circular and continuous. The machine produces the looped fabric with astonishing rapidity; one girl of fifteen or sixteen years old, by attending one machine, can produce material enough in one day for twenty dozen pairs of stockings. To describe in words this beautiful machine is quite impossible; to show how the ten or twelve hundred delicate needles start out and up and down, and loop the thread into a chain as the machine revolves, is impracticable without many delicate drawings. Little as may be the skill necessary to learn the use of the ordinary stocking-frame, this new machine requires less—a woman turns a handle, as if it were that of a barrel-organ, and a stocking, or a jacket, or a petticoat weaves itself.

Besides the circular machines, other knitting machines of smaller pretensions have been produced. Messrs. Whitworth, the celebrated machinists, have patented one of this kind, to be worked either by hand or steam power; it knits one stitch at a time, similar to hand-knitting. A small machine for a similar purpose has also been patented by a Mr. Eastman in the United States. One of the prettiest knitting machines on a small scale is that of M. Lauenville, for making purses, watch-guards, and such like trifles. Although only eighteen inches long by twelve in width, it is a perfect maze of intricate little mechanism; a handle is turned (which a child of six years old might do) and presently we see levers, wheels, needles, hooks, pulleys, bobbins, cranks, axles, spindles, sliders—all working among and around each other, and twisting a thread of silk into the form of a purse or other small knitted article.

### Felting; Hats.

One of the most notable applications of wool and other animal fibres to the purposes of dress is that which we owe to the ingenuity of the hat-maker. If it is not fur, it is wool; if not fur or wool, it is silk; one of the three,

or two of the three combined, form the hat-material for nineteen-twentieths of all the male inhabitants of Europe—nay, it is more than this ratio; so much more, indeed, that we can hardly venture to name the limit. Any one may soon satisfy himself of this by glancing at his own countrymen around him, and at pictorial sketches relating to other countries.

The world talked about a 'hat reform' some few months ago; and there seemed a probability that, with our 'wide-awakes' and the varieties of oddly-shaped foreign hats which were visible in London in the busy year 1851, something neat and satisfactory might have been devised. George Cruikshank depicted a few specimens which were 'curiosities,' if not beauties. But the black cylinders still surmount the heads of the noble and the ignoble. And if we effect a change, what shall the substitute be? Shall it be the *fez* of the modern Turks, quite as ungraceful as the hat, but exhibiting some ingenuity in the mode in which it is woven in one piece? Shall it be the graceful *turban*, the shape and folds and colours of which differ in different countries, and in which silk and cotton may be employed in such great diversity? Shall it be the *bernouse* of the Bedouin, that strange sort of cotton head-gear midway between a cowl and a night-cap? Shall it be the high conical *zanzar* or sheep-skin hat of the Persian, the woolly fleece of which shields the head from the heat of the sun? Shall it be a French dress hat, which you may tuck under your arm, or sit upon, or almost put into your pocket; or shall it be a Scotch bonnet, which you may subject to almost any amount of rough usage with impunity? Shall it be the hemispherical white felt skull-cap as worn by the potters of Staffordshire; or the muffin-cap of the un-dress life-guardsman; or the shapeless but sun-shielding slouch hat of the Italian organ-boy; or the gracefully drooping but not slouching hat of 'Spanish minstrels;' or the odd little cap of the French soldiers, which we see alike in pictures of distinguished officers and of the humblest 'Jeannot?' Until these questions are answered, 'beavers' and 'gossamers' must continue their reign.

To those who were so disposed, there were at the Great Exhibition facilities for a sort of extemporaneous apprenticeship to the trade of hat-making. Messrs. Gaimes and Sanders' model was quite a curiosity in its way. There were the miniature shops and rooms; the miniature model men and model women, each about two inches high, making hats; the miniature irons, rounding-machines, rules, brushes, bottles, scissors; the miniature processes of body-making, calico-proofing, stiff-rubbing, cover-stretching, brim-forming, cork-body-making, silk-blocking, silk-finishing, wool-bowing, batt-pressing, cone-felting, &c.; the miniature hot-water tank at which the men work; and even a miniature pint of beer by the side of one of the workmen. Messrs. Christy, too, the head of the trade, effected all that could be effected by exhibiting specimens illustrating the materials for hats in the raw state, the materials prepared for use, and the incipient hat in all the stages of its progress. There were the dark and the light beaver skins; the skins with the coarse hair removed; the skins with the fine fur removed; skins of the musquash, the nutria, the vicugna, the rabbit, and the hare, which now form cheap substitutes for costly beaver; the prepared fur from all these kinds of skin; the English, Saxony, Spanish, and Australian wools for forming the 'body' of a beaver hat; the beautiful machine for fur-cutting; the hat itself, in a dozen different stages of progress—all were there. There was also the interesting series for a silk hat; showing the silk for the plush, the plush itself, the 'ventilating' body of the hat, and this same body clothed with its glossy

silken garment. And not without its interest was the old cocked hat of 1790, with its Excise stamp of 7*s*. 6*d*., which duty was then paid on such hats.

## HAIR-WORK; FURS; FURRIERY.

Hair and fur and wool have so many analogies to connect them, that we cannot always say to which of the three any particular species belongs. Generally speaking, wool is derived from hoofed animals and fur from animals furnished with claws, while hair is obtained more or less from nearly all. But be this as it may, all three are used very largely for man's convenience, either to form part in the production of articles of attire, or for the fabrication of other articles intended either for personal or household adornment.

Hair-working is now made to yield some very curious results. Portraits are formed in hair, with considerable likeness to the individuals, if not with artistic effect. Emblems and symbols of religion, government, arts, sciences, commerce, industry, &c., form another favourite class of representation. Flowers, bouquets, bracelets, brooches, and personal ornaments are made or imitated in immense variety, and in some cases with considerable effect. Devices for the binding of Bibles and Prayer Books have recently been introduced in hair work. Some of the imitations of feathers are truly remarkable, from the delicacy with which all the minute details are wrought out. The French artists work up hair in very elaborate forms with gold or jewels, to form earrings, bracelets, necklaces, brooches, rings, shirt-studs, and such like adornments.

Perhaps the wig-trade is one of the most curious connected with manufactures in hair. The French are famous in this department. There is a regular *hair-harvest* in some of the central districts of France; Paris firms send agents into those districts in the spring of the year, who purchase the beautiful tresses which the country maidens have been cultivating for that purpose: this hair-crop is as much an annual affair as a corn-crop in the fields. The price paid is about threepence (English) per ounce; but the agents usually pay for the hair with ribbons, handkerchiefs, and other trinkets, at fairs and markets. Not the least curious feature is, that the agents can distinguish the hair of one district from that of another not far distant—an ethnographical feat which might puzzle a learned naturalist—and attach a money value to this difference. If it be true, as is asserted, that two hundred thousand pounds weight of women's hair is thus annually sold in the country districts of France, it must be admitted to form a very singular kind of commerce. The agents sort and clean the hair, and then dispose of it to the Paris firms at about double the former price. Then comes the art of the perruquier to fashion this hair into wigs, perukes, and scalps—some of which command a very high price. Of the 'transparent wigs,' the 'ventilating wigs,' the 'bald white wigs,' the 'gossamer-parting wigs,' the 'fronts with each hair fixed separately,' and other wonders of wig-making—our advertising perruquiers have made us abundantly acquainted.

The hair for woven textures, such as hair damask, striped hair seating, hair weft to silk warp, &c., is chiefly horse-hair, taken from the tail, and dyed or otherwise prepared. Weaving such fabrics is a slow and difficult process.

*Fur* is, however, more commercially important than hair. The skins and furs imported by or for our manufacturers are more varied and more numerous, perhaps, than would generally be supposed. When we consider, too, how many countries must be ransacked to produce this variety—the

beaver, the bear, the ermine, the otter, the racoon, the chinchilla, the wolf, the fox, the musquash, the sable, the martin, the squirrel, the fitch, the mink, the seal, and others—it will be plain that the commerce in furs must be considerable. In 1850 the squirrel furs imported exceeded two millions, the musquash one million, the racoon half a million; while the rest made up the total number to nearly five millions—not hides for tanning, be it remembered, but skins imported for the sake of the fur. The beauty of a fur does most unquestionably, in the eye of a purchaser, depend largely on the price he pays for it; and this price depends on the scarcity in the supply. Why else should a black-and-silver fox fur command a price of thirty or forty guineas, or a sea-otter skin still more? It is true that fashion also tends to determine the price; and it seems that the different tastes of different countries curiously illustrate this. Thus, the black-and-silver fox skins are mostly purchased for the Russians and Chinese; the red-fox skins are in demand in the East for cloak linings and dress trimmings; the otter skin is used in the same regions for caps and collars; the beaver fur, now getting out of use for hats, is being made available as a beautiful kind of cloth for dresses; the lynx, now out of fashion in England, is a favourite in America; the wolf yields a coarse fur, which the Russians employ for cloaks and coats; the sable has long been a favourite in England, and when dark in colour commands a high price; the mink (the choicest specimens) is said to be now in high favour in Paris; the musquash is largely used in England, it being made to do duty for more costly furs by a little 'doctoring;' the fur of the black bear is chiefly appropriated by military men, for caps, holsters, rugs, hammer-cloths, &c.; the sea-otter fur is a royal fur in China, and a noble fur in Russia, and hence commands high prices in those countries.

Most of the furs named in the above paragraph are procured from North America, through the medium of the Hudson's Bay Company; but there are some European furs which command an extravagant price. The Russian sable, for instance, will sometimes sell for as much as ten guineas; and so many of these are employed to form a lining for a cloak, that such a lining has not unfrequently involved a cost of a thousand guineas. The Corporation of London display their sable-furred gowns or robes on official occasions. The fur called French sable is really that of the stone martin, which the French show much skill in dyeing. The ermine or minever, from Russia and Sweden, is one of the most remarkable of furs, naturally as well as socially. Its beautiful and delicate white can only be insured by killing the animal in winter, when all is white except the tip of the tail. In social dignities the ermine, perhaps, takes the lead of all furs; for—not only in many countries of the Continent, but in less-despotic England—there is a sumptuary law or custom respecting ermine; the sovereign, the royal family, the peers, the peeresses, and the judges, all wear ermine on state occasions; and this ermine is 'powdered' (as the heralds term it) with small black spots or stripes of some other fur; the number and arrangement of the spots and stripes being indicative of the rank of the wearer, and no deviation therefrom being permitted. For the squirrel fur, which is used in larger quantity in England than any other, we are chiefly indebted to Russia; it is cheaper than any other equal to it in appearance; and some of the white portions are admired for their beauty. The fitch, with its strong and durable fibres, has latterly been passing out of favour. The lamb skin, at a tender age, has all the beauty of fur; and some of the foreign specimens command a high price. The cat skin is now used largely in England as a fur, greatly to the

danger of the domestic 'puss' in general. The rabbit is also an extensively-used fur; and the white varieties are made to do duty as substitutes for ermine. The little chinchilla yields a soft and delicate fur, much used in England and France. Angora goat skin was at one time worn extensively as a fur; but it is now more customary to remove the hair or wool, and manufacture it into cloth. Seal skins, when to be worn as furs, have the long coarse hair removed, and the rich silky down which lies beneath it is dyed of a brownish colour.

When these various furs are gathered together from every quarter of the globe, and consigned to the hands of the furriers, they undergo certain processes, which transform them from quadrupeds' attire into bipeds' attire. The 'pelt,' or hinder surface of each fur, has to be converted into a kind of leather, by greasing, and pressing, and scraping, and other processes; and the hairy or downy surface has to be dyed and prepared in various ways, to develop all the beauty which naturally belongs to it, and sometimes to impart extraneous beauty to it. When the light flocculent down from birds is employed as a fur, it requires much patient labour to adjust all the little fibres to their places, since there is no natural 'pelt' or skin attached to the down when removed from the animal. As instances of this kind of work, we may adduce the Parisian muff and boa lately made from the down of a bird called the egret; their value was one hundred and sixty guineas; there had been only three similar sets previously made—for the Empress of Russia, the Princess Adelaide, and the Duchess de Berri.

## Silk.

One circumstance distinguishes silk from the other three great sources of textile fabrics; viz., the silk is already a continuous filament before it reaches the hands of the manufacturer; whereas cotton, wool, and flax are all short in the fibre; and these fibres have to be combined end to end by spinning. The little silk-worm, intent upon making a warm habitation for himself, wraps or builds around him a cocoon or small egg-shaped hollow envelope, fabricated of one very long and exquisitely fine filament of silk. This filament the silk growers—whether in Italy, Turkey, China, or India (these being the chief silk-producing countries)—unwind by various ingenious means; and many filaments are then combined into one to form a thread sufficiently strong to form into hanks or skeins. Such silk is called *raw* silk, and in this state most of our supply is obtained. It thence follows that the twisting and spinning machinery differs from that employed for the other three kinds of fibre mentioned above. The silk is transferred from hanks to reels, around which it is wound. It is twisted, and wound, and doubled, and wound again, and transferred from one machine to another, until there is sufficient thickness to form a thread for weaving or for sewing, and sufficient twist to give it strength.

Among the novelties of recent years in connection with this beautiful manufacture is the application of the Jacquard apparatus, for weaving figured patterns; or rather, as silk was the first material to which this admirable contrivance was applied, we ought to say that many recent ingenious applications of the Jacquard loom have been made, either to produce novel combinations or to work with more than usual rapidity. Another notable invention is a loom without any shuttle whatever, for weaving fringes and other narrow but

thick silken goods; the silk is threaded into a number of hinged arms or long needles, and then thrown in among the silk weft in a highly ingenious way.

Perhaps the attention to the silkworms themselves, and to the birth (so to speak) and rearing of the silk, is among the most valuable of recent 'curiosities' in this department. M. Duseigneur, an eminent manufacturer at Lyons, has lately shown extraordinary patience, skill, and energy in examining the anatomy of a filament of silk; he has taken filaments of different ages and kinds, magnified them by the microscope, and fixed the images by the photographic process—thus letting each distinct filament tell its own history. It is worth knowing that the Chamber of Commerce at Lyons has assisted M. Duseigneur with funds to conduct these researches, in its desire to foster everything which can possibly improve the silk manufacture; and it is just possible that the "tight little island" might learn a useful lesson therefrom. Another foreigner, Count Brouski, has been growing silk at his estate in Gironde, with a view of increasing the beauty and value of the filament in the highest degree; the quantity, too, seems to have engaged his attention, for the ordinary yield from a cocoon is about five hundred yards, whereas he has caused his silkworms to yield a thousand yards.

With respect to our own country, it is impossible not to feel admiration for the unwearied attempts made by the late Mrs. Whitby to foster the rearing of silkworms in England. True, it is no new idea—this enabling England to rear its own silk for its own manufacturers. It is well known that James I. endeavoured sedulously to bring about such a result, and that the mulberry trees near some of our old mansions are remnants of the attempt. The attempt failed, apparently owing to the coldness of our climate; but this did not deter other experimenters from further trials. In 1718 a silk-rearing company leased Chelsea Park, planted thousands of mulberry trees to feed the silkworms, and built extensive works; but the project failed. So it has been, on a smaller scale, on numerous subsequent occasions. Mrs. Whitby was among the latest, but certainly not the least untiring of the experimenters. This lady, about fifteen years ago, began to attend to the subject of silkworms at her residence in Hampshire; she studied the habits of the little insect, and experimented on the relative value of different kinds of mulberry trees as food; she gave her election in favour of the Philippine mulberry (the *Morus multicaulis*), some seeds of which she imported into England for the purpose. She communicated the results of her experiments to the Royal Agricultural Society and to the British Association from time to time. Writing in 1849, she said:—"There are many persons in England, and a few in Ireland, who have begun the experiment on a small scale; it requires time to mature and perfect any undertaking; but, if I live long enough, and the growth of the mulberry becomes generally encouraged, I have no doubt my ardent wish to see the cultivation of silk established in England will be realised." Mrs. Whitby did not live to witness this realisation; and it may be that modern attempts will fail, as earlier ones have done, to make English silk-rearing a commercially profitable enterprise. Yet was it not a little interesting to see the beautiful banner which was recently made by Messrs. Houldsworth, from silk reared by Mrs. Whitby; the thing *can* be done—but will it 'pay?'

As an interesting fact in recent silkworm statistics, we may mention that M. Nourrigat, a silk rearer of Lunel, in France, placed 24 ounces of silkworm eggs under proper treatment in 1850; the worms consumed many hun-

dredweight of mulberry leaves; and produced 32 cwt. of cocoons, which were sold for somewhat above 300*l*. It thus appears that one ounce weight of these little eggs has in it the 'potentiality' (as Dr. Johnson would, perhaps, have termed it) of more than 12*l*. worth of silk.

### English Silk Towns; Workers and Products.

The silk manufacture has sought out for itself an English home in Spitalfields, Derby, Coventry, Macclesfield, Manchester, and a few other districts—a strangely-scattered domain. It would be pleasant to be able to record any notable advance of Spitalfields and its silk weavers. From the time of the revocation of the Edict of Nantes, more than a century and a half ago, when the French Protestants sought refuge in England, Spitalfields has been one great seat of the silk manufacture. The weavers have often shown the possession of intellectual tastes; they have at different times established a mathematical society, an entomological society, a historical society, and a horticultural society; they have sent forth a Dollond, a Simpson, and other eminent men: they have become proverbial for their humanising love for birds and flowers; and yet—what are they now? They are amongst the most lowly paid of London artizans; their ten or twelve thousand small houses in Bethnal Green and Spitalfields are badly built, badly drained, badly warmed, badly served with the conveniences of life; they walk abroad as a pale, sad, sickly race of men, meanly clad, and insufficiently fed. If it be asked how the Spitalfields weaver has fallen so low, the answer is manifold. The weavers have been in the habit of appealing to public sympathy so often, that they have lost the self-reliance which might otherwise be their stay. They have in such a mistaken spirit called aloud for 'protection,' that they neglected the best of all means of protection, viz., improved mechanical contrivances and improved artistic designs. They have brought up all their children to the same trade, so that there are now too many mouths to be fed by the work which is to be done. That there was no real inevitable reason for the decay of Spitalfields, is shown by the vast spread of the silk manufacture at Manchester. England never produced so many silk goods as she now does, and Spitalfields might have had a share of the increase had she adopted the right course to procure it; but, in truth, that district is behind the age, and suffers accordingly.

Let us, however, not press too hardly on Spitalfields and its weavers. Now that 'protection' to the silk trade is almost universally given up, the Spitalfields manufacturers are showing an energy which was not before exhibited. They have recently produced some silks of especial beauty, and are evidently trying to regain some of their lost ground. The goods manufactured by them are varied—comprising gros-de-Naples, gros-de-tour, gros-royal, ducapes, satins, *glacé* silks, barratheas, Balmorals, paraphantons, armozines, radzimores, levantines, velvets, sarcenets, Persians, and others whose names would be a puzzle to most persons. Among these are beautiful and costly silks, which show that Spitalfields can do worthily if it will. A brocaded silk has been lately produced there, which required thirty thousand Jacquard cards and a hundred shuttles to weave it, and comprised silk of fifteen different colours. We need only mention the 'Spitalfields trophy' to recall to memory a beauteous array of goods from that district—comprising damasks, brocatelles, brocades, and furniture silks of great costliness. Nor should we omit to remark that there is a School of Design in Spitalfields, at which the pupils study

drawing from natural plants and flowers; if the manufacturers foster this praiseworthy attempt on the part of the Government to elevate the tone of designers or pattern-draughtsmen, there may yet be a brighter future for Spitalfields.

Derby is another of the centres of the silk trade, as it has long been. Lombe's Mill is, we believe, still standing on the little island in the midst of the Derwent, where it has been at work for a hundred and thirty years; and there are thirty or forty other factories in which silk is spun into yarn and thread, and then manufactured into ribbons, trimmings, dress silks, hosiery, and other articles. Derby is especially the seat of the silk hosiery trade. Some of the silk factories are very fine and complete establishments, one among the number giving employment to upwards of a thousand hands. The proportion of boys and girls in all such mills is much greater than that of adults; in winding, cleaning, reeling, doubling, warping, filling, picking, and many other processes to which the silk is subjected, boys and girls do the greater part of the work, women the next greatest, and men the least of all; the men's work is chiefly spinning and ribbon-weaving. In the broad-silk manufacture, much of the weaving is done in the villages around Derby, in the houses of the weavers, but in looms belonging to the employers. The employment of boys and girls in any particular manufacture—as in that of silk just adverted to—is productive of results which adult workmen cannot ignore, though they may be very little understood at a distance. Its inevitable tendency is to bring down the adult wages (except for the higher or more skilled departments) to a very humble level: it is thus probably that the silk and stuff manufactures exhibit a lower range of wages than the cotton and woollen manufactures.

As Derby is the silk metropolis in one county, so is Macclesfield in another—Cheshire. Macclesfield depends more exclusively than Derby upon silk; for this is emphatically *the* manufacture of the town. It was one of the towns which took trade away from Spitalfields about half a century ago, on account chiefly of disputes concerning wages. There are large mills in which women, boys, and girls, with a few men, are employed in spinning silk and its preparatory processes; while the weavers work at their own homes, in and around Macclesfield. The chief kinds of silken goods produced here appear to be shawls, handkerchiefs, scarfs, cravats, and gauze veils: plain broad silks, the staple of Spitalfields, are not well understood by the Macclesfield weavers —one among many instances of the force of habit in accustoming a body of men to a particular kind of employment. Nearly all the weaving is effected by hand-looms, very few power-looms being yet employed; and for figured silks the Jacquard loom is in general requisition. Congleton, in the same county, and Leek, in the neigbouring county of Stafford, are two other notable silk towns.

It is a very curious circumstance, that the large old village of Middleton, not five miles from Manchester, and immersed in the very heart of huge factories, panting steam-engines, cotton-spinning machines, and power-looms—is almost wholly inhabited by hand-loom silk weavers. They carry on their handicraft in their own humble dwellings, intermarry with each other's families, keep up many old customs which have become obsolete in most other parts of Lancashire, and sympathise but little with the high-pressure activity of their neighbours. It is said that the introduction of this branch of work at Middleton was brought about thus:—At a time when the power-loom began to exercise a sensible effect on the hand-loom cotton weavers near

Manchester, the Spitalfields weavers were earning a high average rate of wages, and it was thought that Middleton men might earn more at silk than at cotton; it was tried, and seems to have so far succeeded as to have converted Middleton into a silk-weaving village. The inhabitants work cheaply enough, it is true, but their earnings are said to be better than those of Spitalfields.

As to Manchester itself, the great advance made by it in the silk manufacture has been due to the production of *spun* silk. The best silk goods are made of what is called *thrown* silk—the long continuous thread obtained from the silkworm; but the shorter and waste fibres can only be wrought up by processes analogous to those of cotton spinning. Manchester set those processes on foot, and hence has arisen a wholly new branch of industry. All our very cheap silk goods are now made of spun silk (with an unacknowledged quantity of cotton often added), and are made at Manchester. True it is that silks of the highest order are also produced there; but it remains not the less true, that the spinning of waste silk into yarn for cheap goods forms the characteristic of Manchester silk manufactures. It is at Manchester that we may consistently look for the application of steam-power in silk-weaving; such an application has only lately been first made, and it would be unsafe to predict a future career for a system while in its infancy. Yet it is impossible not to see that the silk manufacture at Manchester may lead to great results; for although *cheapness* began it, there is no reason whatever why *excellence* may not mark its subsequent progress, in a town where all the elements of progress are so intensely active. Where the Schwabes and the Houldsworths are engaged, fine yarns and rich fabrics may well be expected. Our modern silk mills have produced yarn or silken thread so fine as to give a length of twenty-four miles to a pound weight; in woven goods some of the modern 'shaded glacé' silks have the threads shaded into twenty different tints by dyeing; and in embroidered goods, we see the effects of Houldsworth's elegant machine, which embroiders both sides of a piece of silk alike.

The Coventry ribbon trade is a puzzle. Why the same town should make watches and ribbons, so dissimilar in material, manufacture, and use, and in such vast quantities, is one of those 'curiosities of industry' which it is rather difficult to understand; but certain it is that the factories of the employers and the humble homes of the employed exhibit these two kinds of manufacture to an extent that quite excludes all others. Floral ribbons, natural history ribbons, heraldic ribbons, architectural ribbons, geometrical ribbons, portrait ribbons, landscape ribbons, scroll ribbons, arabesque ribbons, nondescript ribbons—all are made at Coventry. And so are ribbons of all widths, from an eighth of an inch to nine inches, Until a recent period Coventry aimed rather at the production of cheap than of high-class ribbons; but the removal of 'protective' duties has had an effect here similar to that observable in so many other quarters; it has driven the manufacturer to depend on his own resources; he studies design and artistic grace, he perfects all the mechanical arrangements of his spinning and weaving apparatus, he attends to the chemistry of colours, and hence he is now enabled to show a nearer approach to his *confrères* at Lyons and St. Etienne than at any former period.

When Prince Albert's industrial gathering was about to take place, the Coventry manufacturers adopted an excellent plan to display the present resources of their art. Besides all the ordinary productions of the ribbon-loom, they resolved to produce a specimen which should eclipse all yet done in England. A committee was appointed to superintend the manufacture of

this ribbon, at the joint expense of some of the chief firms; the object in view having relation both to the excellence and the price of the article produced. This was done; and the result was a ribbon which has, perhaps, never been equalled in this country. That our Coventry men can equal the ribbon-weavers of France, perhaps they themselves would hardly assert; but they are working onward in good heart towards that object. Coventry is not the only ribbon town in Warwickshire; it is the centre of a system, and has Nuneaton and other towns for satellites. The satellites, too, are aiming to equal the greater body in merit if not in size. Nuneaton, for instance, has recently produced a 'garniture-ribbon' which required 1700 Jacquard cards to weave. This designation, 'garniture-ribbon' is better understood by ladies than by men-folk; it relates to two ribbons of similar pattern, the one wide and the other narrow, and applied in dress in certain relations to each other. In the instance in question, the wide ribbon required 900 and the narrow 800 Jacquard cards.

Dublin and Norwich, widely as they are separated topographically, present some singular analogies in respect to silk manufactures. Each has acquired a fame for the production of certain silk goods, or rather goods in which silk and worsted or woollen are mixed. Who has not heard of Irish poplins? They have a wide reputation among those who admire good workmanship and are willing to pay an adequate price for it. These poplins comprise silk for the warp threads and worsted for the weft; but there are other textile goods—damasks, tabinets, tabarets, &c.,—for which Dublin is famed. In Norwich, however, the variety is more considerable; poplins, bombazeens, crapes, paramattas, challis, chinés, silk and barège shawls, stuffs, camlets, 'Lindianas' (a cunningly-devised name to catch customers)—all are made at Norwich: some are silk, some worsted, some a mixture of the two. Bombazeen—resembling poplin in so far as it has a silk warp and worsted weft—is a Norwich manufacture which fashion has almost completely killed; scarcely a vestige of it remains, cheaper goods having superseded it. In respect to poplins, Norwich is cheaper than Dublin, but Dublin is better than Norwich. Norwich, at the present time, exemplifies the large amount of work rendered for a small amount of pay in some of the departments of the silk manufacture; the weavers work at home, at the hand-loom, and pay girls or women for winding the silk on the bobbins of the shuttles; now these girls wind a dozen skeins of 560 yards each, making nearly *four miles* of silk thread, for about *one penny!*

We are not able, while thus speaking of silk, to record any progress in the use of certain substitutes for that delicate substance. There was a time when the *pinna*, a monster mussel two feet in length, was made to yield up its *byssus* as a silky material; this byssus is a bundle of delicate fibres, with which the animal attaches itself to rocks or to the shore. And even at the present day the Sicilians are said to catch the pinna, eat its flesh, spin the byssus into fine yarn, and knit this yarn into stockings, gloves, caps, and other light articles. We are told, too, of the cocoon of the spider being used as a material for making the most gossamer-like gloves ever worn by human hand.

But until these or other substitutes for silk become more commercially available, we need not dwell further on their 'curiosities.'

## Shawls; Glass-Tissue; Embroidery Machines.

The shawl manufacture has an interesting history, not only in respect to its eastern origin, but to its remarkable location in certain towns in Britain, and to the ingenuity displayed in its management. India shawls are still, as they have long been, greatly coveted by those who possess the means of purchasing such costly productions. The colours are in general very splendid, like the flowers and plumage of the sunny south; and although the spinning and weaving apparatus are of the rudest possible kind, these shawls are wrought with a high degree of delicacy. The patterns are strange, scarcely admitting of description; yet so identified have they become with the shawls themselves, that our manufacturers imitate them, and can scarcely be brought to attempt anything else. It was about seventy years ago that Norwich began the manufacture of shawls in imitation of those of India; and about the beginning of the present century Paisley entered on a similar course. Shawls of a different kind were made in those towns previously; but the rise of a profitable market for India shawls led our manufacturers to try their skill in imitation. Those who could pay for real India shawls did so; those who could not, preferred French shawls to those of Norwich and Paisley; and it was not until the Jacquard loom facilitated the production of shawls quickly and cheaply, that our home sale became large.

The variety in shawls is rendered yet more striking by the recent introduction of printing as a means of producing the whole or a part of the coloured pattern. There are a few print-works in the home counties, at Crayford, Merton, and elsewhere, where this higher class of printing is conducted. The processes are slow, and require much care; cheapness is not attempted; but shawls and other goods are produced of exquisite beauty by the block-printing method. The material called *barège* is now wrought into printed shawls of great delicacy.

There is one 'curiosity' or novelty in the silk manufacture, the very name of which is so beautiful that one feels as if it ought to establish a place for itself in public favour. *Tissue de verre—glass-tissue*—the designation points to something delicate, graceful, glossy, rich. We must of course dismiss from our minds the rigid characteristics of glass in its more familiar forms, and think only of the tender filaments which are drawn out by means of the blowpipe and the spirit lamp. One of the very prettiest of work-bench processes is this glass-spinning, as carried on at the Polytechnic Institution and other places to which the public have access. The softened ductile glass, attached to a sort of spinning wheel at one end, and exposed to the action of a flame at the other, yields to the double influence, and spins out into a perfectly even and fine crystal thread. When thousands of these threads are grouped side by side, nothing can exceed their lustrous beauty; and we need scarcely wonder that the display should suggest the use of such fibres in woven goods. A patented method has been devised; the glass threads are combined with other threads of silk, or of gold and silver, and woven into a delicate tissue, which may have the characteristics of satin, or velvet, or brocade, according to the mode in which the weaving is conducted. The manufacture is very difficult; for the glassy filaments are of course fragile; and the time has not yet arrived when the novelty will be commercially advantageous to the inventor; like many others, it is too costly to have a large sale, and will scarcely pay with a

very small sale. A glass slipper may, however, by and by, be something else than a mere Cinderella legend.

But to return to our silks. A curious idea has been lately put forth by Mr. Hutchison, of Paisley, for inventing patterns *ad infinitum;* he has patented it, and a brother townsman has devised the means for putting it in operation. It is intended for application to any woven goods—silk, woollen, worsted, cotton, flax, or any combination of them; and the patterns to be produced are stripes, checks, and tartans. The mode of procedure has some analogy to that of the once famous but now neglected kaleidoscope, the patterns being produced by coloured glass and sliding mirrors. The inventor tells us that "the advantages of this machine are—the facility with which any pattern, or idea of a pattern, may be set up and displayed; the variety of designs it can produce; and the ease and simplicity of accomplishing them. It is not at all necessary to paint the pattern on paper after viewing it through the mirrors, as the scales attached show at once the required number of threads of each colour, and how many repeats are necessary for the breadth of the web; and it displays at once, not only the repeat, but the whole breadth and a considerable portion of the length of cloth at one view. By this invention, the precise effect of a pattern may be produced, in the course of a few minutes, without any expense, multiplied to any extent, and it may be enlarged or diminished at pleasure." It is obvious that, so long as straight lines bound every part of the pattern, an interminable variety might be produced by combining different coloured glasses. The idea is not without its ingenuity; but in a country where artistic taste in design is confessedly lower than in France, it seems scarcely desirable to lead designers to a *mechanical* mode of producing the patterns they require. If we can produce graceful curves, intersecting straight lines will almost produce themselves.

Some of the 'curiosities' of modern ingenuity consist in the expenditure of an enormous amount of money, time, patience, and skill, in producing pictorial representations on woven fabrics for which they are quite unfitted. Persons of taste have not yet quite agreed what are really the best classes of designs for carpets, wall-papers, furniture damasks, table linen, and dress silks and fancy goods; but there is a growing perception of a certain measure of agreement which ought to subsist between these articles and the purposes to which they are applied. To trample a temple underfoot, in a carpet design, is not satisfactory; nor is it rational to build cottages or gothic porches one over another, from the floor to the ceiling, in a wall-paper; nor does a royal portrait look consistent in a table cloth or a pocket handkerchief—to be covered with hot dishes in the one case, and to be applied to the nose in the other.

While speaking of silks and velvets, woollens and worsteds, we may say a few words concerning the mechanical application of those materials. Whether, when so many thousand sempstresses and slop-tailors are barely earning the means of existence, machines need be invented for expeditious sewing and stitching, will be determined differently according to the aspect in which the subject is viewed; but such machines have certainly been introduced. Witness that of M. Maguin Villefranche, a recent French invention for stitching. The piece of cloth is laid down flat upon a cushion; the sempstress who works the machine sits at a kind of lathe on which the cushion is laid, and works a treadle with her foot; at each movement of the treadle a needle descends vertically and pierces the cloth, carrying with it a thread; the needle has a

small hook or notch on one side, which catches and brings up a thread on its return from the hole; and thus, two or three hundred times in a minute, a thread becomes interlaced in the cloth in the manner of 'chain-stitch' or 'tambour-work.' The machine, which costs twenty or thirty guineas, can embroider as much cloth in an hour as an embroideress can complete in a day. Another French machine, by M. Seneschal, of Paris, is more complex in its construction, and is intended for sewing coarse cloth. Great ingenuity is shown in the arrangement of the several parts; the machine pierces its own holes, inserts its own thread, tightens the thread after insertion, and shifts the cloth as the work advances, at the rate of forty or fifty stitches a minute. England, too, has not thought such machines beneath her notice. There is Barlow's patent stitching machine, for making articles of dress; two distinct threads are used, one at the front and the other at the back of the fabric, so that each stitch forms an independent fastening. There is Judkins' sewing machine, said to be "suited to sewing either a circle, curve, or straight line, at the rate of 500 stitches per minute;" there are racks or toothed arms employed, straight or curved, according to the shape of the work to be done; there are two threads, one in a reel and one in a shuttle; and a needle ingeniously entangles these threads one in another, through the holes pierced in the cloth. There is Mather's sewing machine, working out similar results by different means. The United States, too, have contributed to this class of machines. Of Morey's sewing machine, made at Boston, the following character is given:—"By a very simple process, straight and curvilinear seams are sewn in cotton, linen, or woollen cloth with great rapidity; with one attendant, it will accomplish the work of five sempstresses; it is easily wrought, is not liable to get out of repair, and is readily applicable to almost every variety of plain stitch; in the large ready-made clothing establishments in the United States it is universally used."

### Feathers.

The last of these useful animal contributions to our wants which will be noticed here are *feathers.*

Feathers, as a filamentous material, seem to have attracted admiration chiefly on account of the exceedingly beautiful forms which they naturally assume, but also for the brilliant colours which many of them display. Feathers, we know, give us—besides the beauteous plumes—articles which are valuable either for the elasticity and hollowness of the quill, or for the softness of the barbs. They give us the quill pens which, notwithstanding the competition of steel, are still made and sold and used in millions annually. But we are here speaking of feathers only in their relation to the labours of the plumassier and the feather-bed maker.

One of the most notable of these decorative feathers is that of the ostrich—that appendage which makes the martial appearance of the soldier still more martial. It is the long feathers of the wings and the tail which constitute the ordinary ostrich plume. The animal is captured and killed with much care, to prevent any injury to the plumage. The feathers are sorted into various qualities, scoured or cleaned, bleached, dried, shaken, and opened, the ribs scraped with a bit of glass, the filaments made to assume a curly form by scraping, dyed or not according to circumstances, and adapted for adjustment in military hats or other garments. Those who are versed in the heraldry of pomp and formality would know the ostrich plumes worn by the

Knights of the Garter or the Knights Grand Crosses of the Bath from the court plumes adapted for ladies, and the black plumes for officers of the Highland regiments. In recent years, means have been devised for imparting brilliant dyes to ostrich feathers, several different colours to one feather, gradually shaded or blended one into another. Then, besides the ostrich, we have the feathers of the marabout, the ibis, the bird of paradise, the vulture or rhea, the emu, the heron, the plotus, the egret, the pheasant, the peacock, the turkey, the swan, the eagle, and some other birds—all applied as ornaments to dress. Some of these are very costly; some are used almost exclusively for one particular purpose; while others have their fashionable and unfashionable periods in public favour. Some of the marabout feathers are knotted with gold, to make a costly trimming for dresses. The emu feathers are more worn on the Continent than in England. The heron feathers, worn by the Knights of the Garter, frequently cost fifty guineas the plume, and sometimes above a hundred guineas, on account of their scarcity. The large egret feathers are worn by the Hussars.

It is a departure, perhaps, from strictly good taste, to use one beautiful material as a means of merely imitating another which is much more abundant; feathers are Nature's ornaments, and so are flowers; but this affords no reason for employing the former to imitate the latter. Nevertheless feather-flowers, as examples of patient manipulation, are sometimes very admirable.

It lies not exactly in our path to talk about bed-feathers and their preparation; but it is worth while to remember that our forefathers were obliged to 'rough it,' in their bed-room arrangements, to a degree that would appear a little strange to the soft-lying dwellers in the nineteenth century. In the days of the Henrys and the Edwards, bed cases or ticks, filled with straw or heath, or chaff, were slept on by the gentry. When feathers became substituted for these less yielding kinds of stuffing, a most paternal care was displayed lest the health of the sovereign's liege subject should be injured by sleeping upon hair, or down, or feathers, unless in a duly prepared state. For instance, no feather-beds were to be sold if scalded feathers were mixed with the dry-pulled feathers; no down-beds were allowed to have fen-down (from the geese of the Lincolnshire fens) mixed with clean down; and no beds or mattresses were to be stuffed with horse-hair, goat's hair, or neat's hair. It is worthy of note, in relation to the development of Australian industry, that the feathers of the sooty petrel, found in immense numbers near Bass Strait, are now coming extensively into use as bed-feathers.

Mr. Booth, a feather-purifier of Cork, has recently obtained a patent for a curious application of the material now under notice. He manufactures a kind of textile fabric, composed of parts or strippings of feathers sewn on to any kind of woven material; the pieces being so close together as to present a continuous feathery or downy appearance. The feathers preferred are those of the turkey, from which the filamentous or downy portions are stripped off in such a manner as to bring with them a slip of the skin or cuticle of the quill; these skin-like terminations furnish the means of securing the feather to the cloth, by sewing them with a needle and thread. The material thus produced would constitute a sort of down-velvet or velvet-down, and might unquestionably have a very beautiful appearance imparted to it; but it must necessarily be costly.

# THE CHEMISTRY OF MANUFACTURES.

It is difficult to say whether productive industry is more indebted to mechanical skill or to chemistry for its recent astonishing advance. Indeed this may be an insoluble problem: for almost every mechanical process requires the aid of chemistry in its development; while chemistry would be nothing without the aid of the machines, the furnaces, and the vessels which permit the processes to be carried on. What we have to do is, to estimate properly both these invaluable assistants to our industry, without establishing a rivalry between them.

The 'curiosities' of chemistry, in its application to manufactures, are many and varied; and we will attempt a brief notice of some of them.

### The Chemistry of Metal-Working.

Let us begin with a few miscellaneous facts relating to metals—those remarkable material products without which man could never have risen far above the level of the brutes, even if existence itself were possible.

The chemistry of the lead-works is often very interesting, and, in some cases, really beautiful. The metal is mostly obtained in this country by operating upon galena or sulphuret of lead, a hard grayish substance found in considerable quantity in Derbyshire, Northumberland, and other counties. The problem here is, how to get rid of the sulphur which forms one component of the galena; and it is found that the best way to effect this is to give a dose of oxygen by some means, so that the union of the sulphur with the oxygen may carry off both in the form of sulphurous acid gas. The galena is roasted in a furnace, under circumstances which produce this result, and the lead is separated in a metallic form. But some of the highly heated lead goes off in the state of vapour, and a sad perplexity this is to the smelter; for lead-fumes are so deadly poisonous that he tries all practicable means to catch the vapour before it flies off into the atmosphere, and retransform it into the solid state. These processes are not particularly remarkable; but another, which generally follows, is much more so. Nearly all lead ore contains a little silver, and it is usually worth while to incur the trouble and expense of extracting this silver. When the metallic lead has been prepared from the galena, if it is found to contain even so minute a quantity as five ounces of silver to a ton of lead, it is deemed worth while to subject it to a refining process, for the sake of the silver. The lead of the Northumberland and Cumberland district averages about ten ounces of silver to the ton; and it will therefore warrant the adoption of this process, where operations are conducted on a large scale; some specimens give as high a ratio as a hundred ounces. The pigs of lead are slowly melted in huge iron

vessels, the molten metal being kept stirred. Portions of the lead crystallise while cooling, fall to the bottom, and are removed by a perforated ladle: and as these crystals contain less silver than the remaining uncrystallised portion, their removal leaves the molten mass richer than before. So matters go on, re-melting and re-crystallising, until perhaps one-twentieth part of the lead contains the whole of the silver. This reduced portion is then exposed to the intense heat of a cupel furnace; the lead combines with oxygen to form litharge, and the silver is separated in a beautiful brilliant cake. Some of the wealthy owners of lead-mines have had costly and magnificent services of plate manufactured from silver obtained wholly by refining the lead.

Copper, again, has its curiosities of manufacture. Nearly all the copper ore that is raised in England, or brought to England, is smelted in South Wales; yet scarcely a particle of this ore is found in that region. Commercial reasons alone have determined the singular location; South Wales can send coal for the steam-engines of Cornwall, and Cornwall can send back copper ore to be smelted in South Wales. The Swansea district now smelts something near 200,000 tons of copper ore yearly, from which about 20,000 tons of pure copper result, worth a million and a half sterling. About ten or a dozen great firms monopolise the whole of this trade. The smelters are not employed by the mine owners to smelt the ore; they purchase it on speculation, smelt it, and then find a market for the metallic copper. The sellers and the buyers form a snug little sort of family party, which meets once a fortnight in a hotel at Swansea; they all know each other, and every firm is fully cognizant of the purchases made by the others. The sale is not by auction, but by tender for each lot or 'ticketing;' and experience has enabled the smelters to approach wonderfully close in their tenders for each particular lot. One of the great firms has been known to spend nearly half a million sterling in one year for copper ore, besides the machinery and the wages necessary to carry on the smelting. Of the smelting itself we need not speak in detail; it comprises sortings and siftings, calcinings and meltings, roastings and oxidisings, and other processes, by which all the sulphur and other substances are driven away, and the pure metallic copper alone is left. One notable curiosity in the manufacture is a very unacceptable one; it is the wreathing cloud of white smoke which hovers over each of the great smelting works, and which has gone far to spoil the once beautiful Swansea valley.

One of the most peculiar circumstances connected with *tin*, in the chemistry of its manufacture, is presented by what is called *tin-plate*. A tin kettle is *not* a tin kettle; if it were, its existence would be very evanescent; for tin will not bear the requisite heat. All tin goods of this kind are made of sheet iron, washed with liquid tin to shield them from rust and from chemical action. The thin sheet iron is cut into quadrangular sheets; these sheets are steeped in muriatic acid, heated in an oven, cooled, straightened and beaten smooth, drawn between rollers, steeped in bran-water, pickled in sulphuric acid, scoured with sand and water, washed in clean water, dipped in melted tallow, dipped in melted tin, drained till dry, and rubbed with bran—an extraordinarily complex series of operations, considering that the film of tin is after all so thin; but all are necessary to ensure an intimate junction of the two metals. South Wales claims to herself the credit of making the best tin-plates in the world.

The wonders of the iron manufacture have engaged a little attention in a former sheet of this work; but a few further notabilities occur to us in

respect to the *hot-blast*. This invention, simple as it may seem, has added almost incalculably to the wealth of our nation. Before this remarkable method was introduced, and when only *cold* air was blown into the iron furnaces, anthracite was too stubborn a kind of coal to be used conveniently as a fuel, and black-band iron-stone was too stubborn a kind of ore to be a favourite among the smelters; but now, when the blast is forced at a high temperature into the smelting furnace, the anthracite is found to yield intense heat, and the black-band to yield a rich percentage of good iron. The market value of the anthracite of South Wales and of the black-band of south Scotland must have been increased by millions sterling by the hot-blast alone. Well may Mr. Neilson be regarded as a public benefactor, by introducing it.

There are other examples in which a great revolution has taken place in one or other of the metal trades, owing to the application of some notable chemical discovery; though few so important in its results as that of the hot-blast. There are also a number of minor curiosities arising from the application of metal refuse to useful purposes. Brass-ashes, or the contents of a furnace in which copper and zinc have been melted to make brass, used to be deemed no better than common ashes and cinders; but it has recently been found that they contain enough of the mixed metals, which reach them in various ways, to give them a commercial value. The ashes become, in fact, a kind of substitute for copper ore, from which copper can be extricated by smelting. It is said that, scarcely a dozen years ago, brass-founders often paid money to have their ashes removed; but that now there are thirty thousand tons which can annually find a ready market, at ten to twenty shillings per ton. Even the slag which results from this smelting is useful; for it is in demand at Swansea to assist as a flux in smelting ordinary copper ore. The slag or dross of iron furnaces has, by the ingenuity of a French inventor, been made applicable to very useful purposes; by a careful process of casting or founding, this slag may be made into paving flags, large building blocks, and even pipes—of great hardness, polish, durability, and cheapness. Lead dross has a commercial value; it forms on the surface of lead while in process of melting; and by careful processes it is made to yield up nearly the whole of the metallic lead which had become combined with it. Type-founders' dross, in like manner, or the dross which forms on the surface of melted type metal, is made to yield up its metallic treasure by subsequent smelting. As to clippings, cuttings, raspings, filings, borings, turnings, sweepings, and other minor fragments of metal which form the refuse of manufactories, it is easy to see how they may be made available in the production of clean good metal.

Of gold a previous sheet has jotted down a few of the 'curiosities;' and we can here only say that the marvels of the 'diggings' in Australia continue to increase. *Two tons* of pure gold have been brought over in one ship.

There is a modern metal, or a metal of modern discovery, the chemistry of which is rendered remarkable by the unconquerable properties (if we may so speak) of the metal itself; this is *platinum*. It differs from all other metals in respect to the great difficulty with which it is brought into the ordinary metallic form. It is usually found, mixed with other rare metals, in grains or small pieces in sandy formations. To melt it into a mass is out of the question, on account of its extreme infusibility; and although it may be welded when softened by heat, yet the extreme slowness and difficulty of the process are such as to render the attempt almost hopeless. Had not Dr.

Wollaston discovered a better method, this invaluable metal would have remained almost valueless; for unless it can be brought into the form of a continuous sheet, crucibles and vessels could not be made from it. Wollaston showed how, by a particular mode of chemical treatment, platinum can be separated from the other constituents of the grains in the form of a fine black powder; how this powder, by the combined action of heat and intense pressure in steel moulds, can be condensed into a solid ingot or block; and how this block can be forged under a hammer to a proper degree of toughness and to any required degree of thinness. The great usefulness of this remarkable metal results from the obstinacy with which it resists nearly all external agents; heat, light, air, moisture, acids, alkalies—all alike are nearly powerless in respect to this refractory substance. Hence its importance in the fabrication of vessels for chemical purposes. Sulphuric-acid stills, crucibles, capsules, &c., are of great value when made of this material. At one time its price was almost fabulous. A manufacturing chemist in the north gave a thousand guineas for a sulphuric-acid still made of a thousand ounces of platinum.

## Chemistry of Paints and Colours.

It would be impossible to notice here more than a very small portion of the 'curiosities' which mark the chemistry of metals during the transformations incident to manufacturing processes. Sometimes the metallic or reguline state, sometimes the oxide or the chloride, sometimes the compounds with acids, present these remarkable aspects; and the treatises on chemistry are full of such examples. Our few instances above must be accepted as specimens; and the beautiful subject of the chemistry of *colours* will furnish us with a little further illustration.

The *zinc-paint*, now brought industriously before public notice, illustrates at once the ingenuity shown in devising means for remedying an evil, and the difficulty of applying the remedy in opposition to popular custom. White-lead is deleterious to health, and nothing has succeeded in rendering it otherwise. Hence attempts are being made to find a substitute; and zinc seems at present the best fitted for this office. The manufacture of the white oxide of zinc is a beautiful example of chemical action. Metallic zinc is heated in a furnace to which a current of air is admitted; the zinc vapourises; the vapour passes into a series of chambers; and here it collects on the walls as a light downy flocculent oxide, which is scraped off and removed. When ground up with linseed oil, the oxide forms a white paint, which may be the ground or substance for other colours used in house-painting. Then comes the rivalry between the two 'whites'—the oxide of zinc and the carbonate of lead. The chemical virtues of the former are insisted upon; but the advocates for the latter have not failed to point out qualities in which it is unquestionably the better of the two—especially in drying more quickly than the zinc-white, and having more 'body' or substance. One among many proposed modes of applying the zinc-white is in floor-cloth painting. In this manufacture, as every one knows, oil paint is laid on thickly, first with a brush and afterwards through the medium of carved blocks. The quantity of paint consumed is so large, that the white-lead contained in it becomes a sad enemy to the men employed in the processes; and hence a recent attempt has been made to adopt zinc-white as a substitute. At present the result is considered to be unsatisfactory in some respects; and we must therefore wait for better.

One thing at least seems undisputed, that zinc-white is less deleterious than white-lead.

This white-lead is ordinarily produced in a way still more remarkable than zinc-white. Let the reader picture to himself the following scene, and the actors in the scene. There is a large lofty room, with an earthen floor. On the floor is strewed a layer of ashes; on the ashes is placed a stratum of tanners' spent bark, two or three feet in thickness; on the bark are hundreds of earthen pots, placed closely side by side, and each containing about a pint of vinegar; on the earthen pots are layers, five or six in depth, of plates of lead, about an eighth of an inch in thickness; on the lead is a covering of boards; then other superposed series of tan, vinegar pots, lead, and boards—tan, vinegar pots, lead, and boards—and so on, until the mass is built up to a height of twenty feet or more. Women do the work; they cast the lead plates, they fill the vinegar pots, and they build up the curious structure—or it is at least true that, in the Newcastle district, where white-lead is made in immense quantity, more women than men are thus employed. The heterogeneous strata—often comprising ten thousand pots of vinegar and thirty tons of lead—being then closed in for several weeks, what ensues? The spent tan gives off heat; this heat evaporates the vinegar: the vinegar vapour acts upon the lead; and by a series of chemical actions the surface of the lead becomes changed into a white carbonate, which then constitutes white-lead.

This process is so tediously slow, that chemists are seeking around them for one more expeditious. Mr. Pattinson, of Newcastle, one of our leading manufacturing chemists, has succeeded in producing what he calls *oxichloride of lead*—manufactured directly from the mineral galena or sulphuret of lead, without all the parade of vinegar pots and tanners' bark; it is cheaper than white-lead; but its introduction has been too recent to determine its relative excellence as a colour-material. Ten thousand tons, or more than twenty million pounds, of white-lead are said to be produced annually in Great Britain; and there is thus great inducement to seek for new and improved processes. So enormous is the quantity of spent tan required for this singular operation, that the manufacture can only be carried on in the vicinity of tan-yards.

It is a most remarkable circumstance in respect to lead, that—dull and neutral as it is in its metallic state—it is the source whence many of our most brilliant colours are obtained. The carbonate of lead, or white-lead, is chiefly valuable as a groundwork for other pigments; but many of the other salts of this metal give to the painter some of his most lively tints. Take, for instance, the compounds of chromic acid with oxide of lead; these produce the beautiful yellow and red chromates of lead. Take, also, the compounds of bichromate of potash with lead; these yield the well-known chrome-yellow. If tell-tale chemistry speaks the truth, chrome-yellow takes part in the manufacture of our common mustards, being used to give the requisite yellow tint to the flour or oatmeal with which the mustard is said to be often plentifully mixed.

This relation between the metals and the colours used for painting is very intimate. Iron, for instance, is the source of many of the colours employed by the painter and the calico-printer. When the beautiful yellow prussiate of potash is combined with iron, there results the well-known Prussian blue, which is so largely employed by paper-makers and paper-hanging manufacturers. Then, again, if this Prussian blue be mixed with chrome-yellow, there is produced one among the many beautiful varieties of green.

But copper is, perhaps, a more prolific source of colouring materials than iron. The deadly arsenious acid forms with copper the brilliant Scheele's green, which—when used, as it often is, in painting sweetmeats and toys—is a dangerously poisonous enemy. When copper is combined with lime instead of arsenic, another tint of green is produced. The singularly veined carbonate of copper, lately rendered so familiar to us under the name of *malachite*, is sometimes ground to powder to form a useful but somewhat costly green colour for artists. But sulphate of copper, more popularly known by the name of *blue vitriol*, is one of the most beautiful and remarkable of these copper blues; the crystalline masses in which it is sometimes exhibited are indescribably splendid. Nor is its mode of production uninstructive or uninteresting. When a ship returns from a long course of voyaging, battered and worn, its copper sheathing is often found to be ill fitted to bear further wear; it is stripped off, and replaced with new. Among other purposes to which this old copper is applied is that of making blue vitriol; it is roasted in a furnace until it becomes converted into an oxide, and this oxide of copper is made to combine with sulphuric acid, and crystallise into the beautiful blue sulphate.

One of the most extraordinary metallic colours, however, in respect to the mode in which it is produced, is unquestionably *vermilion*. Chemistry presents few transformations more striking than this. If the reader were to submit to himself the question, what colour and what form of substance would result from melting together solid yellow brimstone and liquid white quicksilver, he would guess long before he hit upon the correct reply. The substance thus produced is the lovely red powder known to every one by the name of vermilion. How, when the melted sulphur combines with the heated mercury, change of state and change of colour ensue, is yet a mystery; chemists only know that such is the case—they cannot yet dive into corpuscular secrets.

The exquisite blue colour *ultramarine*—in respect both to its natural origin and to its factitious imitation—is one of the most interesting of colouring substances. The blue is intensely vivid, and possesses the valuable property of being almost unalterable by time—so much so, indeed, that when all the other colours of a picture have faded, the ultramarine blue remains as bright as ever, rather to the detriment of the harmony of colour in the picture. It is procured from a blue mineral called *lapis lazuli*, which is occasionally found as a vein in masses of granite in Bokhara and other countries. The stone is roasted by heat, and pounded to powder; it is then mixed with oil, wax, pitch, and other substances, and melted, which enables the colouring matter to separate from the other ingredients of the stone, and fall to the bottom. So rare is the mineral itself, and so difficult the process of preparation, that the exquisite blue ultramarine powder is often valued at its weight in gold—nay, there has lately been exhibited a specimen valued at twenty guineas per ounce.

That chemists and manufacturers should endeavour to imitate this costly pigment, is what might reasonably be expected. During the last twenty-four years Gmelin, Persoz, Robiquet, and others, have devised modes of producing very excellent substitutes for ultramarine; so cheaply, too, that a blue colour, more beautiful, intense, and brilliant than smalt, can now be obtained for fifteen pence per pound. This novelty is seriously affecting the smalt dealers of Saxony; for, by a clumsy anomaly in our customs tariff, smalt pays an import duty of 10s. per cwt., whereas ultramarine is admitted duty free.

The blue colour called *smalt* just adverted to, and of which little less than two million pounds are manufactured annually, has many interesting points connected with its production. Mr. Tomlinson, in a valuable paper read before the Society of Arts in 1851, remarked:—"I think I may safely affirm, that the blue colour which is so extensively used in painting and varnishing porcelain and earthenware, for tinging crystal, and for enamelling, for imitating opaque and transparent precious stones, for imparting a magnificent blue to glass, for giving a blue tint to writing-paper and to linen, for fresco-painting, for the blue figures which adorn paper-hangings—that the blue colour for these and for various other useful purposes in our arts and manufactures, is almost entirely obtained from two small districts, one in Saxony and the other in Norway."

The discovery of smalt, or rather of the *cobalt* from which it is made, was closely connected with the legends of mining. In the mountainous district on the confines of Saxony and Bohemia, there have for many ages been valuable silver-mines; and three or four centuries ago there was a belief in kobolds, or spirits, who protected the metallic riches of the mines. The silver ore became by degrees depreciated by the admixture of a brownish ore which no one could understand; it was thought the kobolds had spitefully converted the silver ore into this brownish rubbish; and the rubbish came by degrees to receive the name of the mischievous spirit himself. A glass-maker, however, on trying to melt some of this ore, found himself enabled by its means to impart a beautiful colour to glass; and from that day the much-despised kobold (or *cobalt* in modern orthography) became a valuable material.

The manufacture of smalt from cobalt is rather a complicated operation. The Swedish chemist Brandt found out that the mineral in its purest state is the oxide of a metal, to which he gave the name of cobalt. The ore, however, as met with in the mines, is a very complex affair; it contains not only cobalt, but also iron, nickel, bismuth, sulphur, and arsenic—all of which must be driven off before the beautiful blue colour can be obtained. The ore is stamped into fragments; it is plentifully washed with water; it is roasted for many hours in a reverberatory furnace, to get rid of many impurities; it is mixed with calcined quartz and purified potash; the mixture is melted in pots, in a furnace somewhat resembling that used by the glass-maker; the resulting melted compound is a blue glass, which is poured out in a white liquid state into cold water; the *smalt* thus produced is crushed, sifted, ground, washed, and otherwise reduced to a fine powder, which constitutes (according to its quality) the *azure* and *smalt* of the colour-dealer—varying in their delicate blue hues by almost imperceptible shades. The commonest kind of smalt is called *zaffre*. A part of the smalt used in this country is prepared at Birmingham; it is separated from the nickel with which the so-called 'German silver' is made, and is then sent to Staffordshire to be employed in painting porcelain.

In reference to artists' colours, modern chemical discoveries and inventions have enabled them to be produced at much cheaper prices than at any former period. The Society of Arts has recently put this question to the test. Wishing to aid in this matter, the Society offered a prize for the best box of water-colours which could be sold retail at one shilling—undertaking to purchase a certain number, to give a commercial start to the undertaking. The prize has been competed for and gained; and an excellent shilling box of colours is the result.

## The Chemistry of Dyeing and Calico-Printing.

Colour-chemistry has no more beautiful and important application than in the dyeing and printing of textile manufactures.

When a piece of cloth is dyed, does the colouring matter combine chemically with the filament, or does it simply lodge in little cells? Chemists and scientific dyers have long been discussing this question, but without arriving at undoubted results. All that seems to be known is, that if any one particular dye be applied to textile materials of cotton, flax, hemp, silk, wool, fur, or hair, it will adhere to them with different degrees of firmness, and will present different degrees of brilliancy, according to the nature of the filament. Whether there be an attraction or affinity (as chemists term it) between the filament and the dye, varying in strength in different instances; or whether the little cells or pores of the filament bear a certain relation in size to the dye particles—seems to be left for the determination of science at some future period.

But there is another souree of diversity in the relations which dyes bear to the various filamentous substances above named. Whether it is that the cells of the filament and the particles of the dye do not suit each other in size without a little 'doctoring,' or whether principles of a more chemical character are at work, it is seldom that a piece of cloth will receive a dye without the intervention of some third material—some friendly agent which will adapt the other two to each other. All such agents are called by the dyer *mordants;* they have a 'biting' action (as the origin of the word shows); they bite the dye into the filament. Thus there arises a great diversity in mordants; for they depend not only on the nature of the dye which is to penetrate, but also on that of the filament which is to be penetrated.

But the chemistry of dyeing and calico-printing is far more complex than the 'mordants' seem to imply. There are no less than six different kinds of effect to be produced on woven cotton goods, by chemical means, before the dyeing and printing can be fully attained. One is the *cleaning*, the removal of all extraneous matters from the filaments; another is the *colouring*, or the imparting of actual tint to the cloth; a third is the *fixing*, or compulsory union of the dye with the cloth through the medium of a mordant; a fourth is the *discharging*, or the removal of colour from particular parts of the cloth by chemicals subsequently applied; a fifth is the *protecting*, or shielding the cloth from the action of particular colours at particular spots by a preparation called a 'resist;' and lastly, a sixth is the *brightening*, or the development of the beauty of the colours by an after application of certain chemicals. Now every one of these six effects has its own particular group of agents—its own range of chemical substances fitted to produce it—its own peculiar connection with the chemistry of colours; and it is scarcely too much to say that almost every discovery in chemistry is made available for one or other of the above six kinds of service.

To enumerate the crystals, the liquids, the powders, the gases thus employed, would take us a long journey through the range of acids, alkalies, salts, earths, and other bodies on which the attention of the chemist is bestowed. Sulphur assists in bleaching, and is the source whence the invaluable sulphuric acid is obtained; and this sulphuric acid is one of the means for obtaining the chlorine, the muriatic acid, and the soda, which enter so largely into dyeing and calico-printing. Common salt—the removal of

the duty from which has been an inestimable good to science and manufactures—is, however, the great storehouse for the last-named three substances; sulphur being an agent for developing them from this storehouse. Then, again, there are nitre and nitric acid, hot and biting, to act upon various substances which will not yield to less energetic acids. Then the metals copper, tin, iron, lead, &c.—when in the state of oxide—are most valuable adjuncts to the dyer's store. Again, the acids, when combined with the metals and earths and alkalies, give another series ever widening as chemistry advances. Add sulphuric acid to alumina, and we get alum; add it to iron, and we obtain copperas; add it to copper, and there results blue vitriol; add it to soda, and we produce Glauber's salt; add it to lime, and we obtain plaster of Paris; and so forth. It is not here meant, of course, to imply that if we place the two in contact, the compound named will be immediately produced; but that the compound is the result of the chemical union of those ingredients. Thus it is that, if such organic acids as the acetic, tartaric, or citric, or such mineral acids as the sulphuric, muriatic, or nitric, be made to act upon the oxides of the metals tin, lead, copper, iron, &c.; or upon the earths lime, alumina, &c.; or upon the alkalies soda, potash, or ammonia—there result compounds so numerous as quite to baffle any ordinary enumeration; and it is the duty and the interest of the dyer and the calico-printer to see which of these numerous bodies will be available to him in the production of colour in any one of the six different ways enumerated in the last paragraph. There really seems, therefore, something akin to the apparently inexhaustible powers of a permutation series in the double, triple, and quadruple compounds of chemical substances applicable to the dyer's art.

If we were to classify chemicals according to the dyes which they tend to produce, instead of according to their constituent ingredients, we should find strange companions grouped together. For a yellow colour we should find brilliant crystals obtained from horses' hoofs and blood, and known as prussiate of potash; chromate of potash; fustic wood; quercitron bark; weld and turmeric; and other vegetable substances. If it be red, we have a great variety of sources: there are the little bodies of the cochineal insect and of the lac insect; there are the vermilion and the lake series; and there are numerous mineral substances, such as the acetate of alumina. If it be blue, there are ultramarine and smalt, indigo and weld, and numerous other sources. And so might we glance one by one at all the colours: we should find that the three kingdoms of nature—animal, vegetable, and mineral—all contribute under singularly diverse forms. The colours denominated *lakes* form a curious group. They comprise animal or vegetable juices, rendered opaque and substantial by admixture with alum or some other mineral substance. Carmine, for instance—one of the most beautiful of colours—has for its organic element the little cochineal insect, which forms such an important article of commerce in Mexico. The vegetable substance called madder yields another and cheaper kind of carmine. Brazil-wood, by a peculiar mode of treatment, yields brown lake; while Persian berries, annatto, and quercitron bark are sources whence various kinds of yellow lake are derived.

Great is the array of tubs and vats, boilers and cisterns, employed by those who dye largely in the manufacturing districts; and great the ingenuity required to adapt the means to the end to be attained. Sometimes the cotton or the wool is dyed in the filamentous or unspun state; sometimes as a spun yard or thread; sometimes as a woven cloth. Silk is too fine and fragile to be dyed until after spinning. The chemistry of this dyeing is often very

deep and scientific. Let it be a blue colour which is to be given to cotton cloth, and indigo the dye material. Much management is necessary to fit the agent for the work it has to perform. It is first de-oxidised, to render it soluble, and to enable it to enter the little pores of the filament; and then it is re-oxidised, to fix it in its new home. During this process, it changes to a greenish-yellow colour; but this matters not, since the re-oxidation restores the blue. Chemistry has to entice the indigo to enter the little cells, and then entice it to stay there.

One most important difficulty of the dyer's art is to range all his colours into two groups—*substantive* and *adjective*—comprising those which adhere to the cloth by their own chemical energy, and those which will not constitute 'fast colours' without the aid of a mordant. Not only do dyes differ among themselves in this respect, but one particular dye has different habitudes in relation to different textile materials—cotton will often reject that which wool would receive kindly, and silk yet more kindly; and there has been much more thought and experimental research necessary to obtain brilliant and permanent dyes for cotton, than for silk or wool. In respect to the two designations used above, of substantive and adjective, we may adduce the colours called *lakes* as examples of adjective dyes, which cannot be fixed in the cloth without the aid of a mordant. Whether made from madder, cochineal, Brazil wood, saffron wood, logwood, quercitron, fustic, or weld; whether called red, crimson, purple, black, or yellow—all lakes seem to have this fugitive character, unless rendered substantive and fixed by the aid of a mordant.

Nothing can better illustrate the extraordinary complexity which sometimes marks the operations of the dyer, than the mode of producing the celebrated *Turkey red* dye—that which has been brought so much into favour by the bandana handkerchiefs. Here the brilliant tint is obtained by a long series of processes, each of which is intended to effect one particular change in the relation between the materials and the cloth. The cloth is steeped in an oily liquid; it is allowed to ferment or 'sweat' for several hours; it is exposed to the heat of a hot closet for several more hours; these three processes are repeated a second time, and then a third time; the cloth is steeped in an alkaline liquid; it is steeped in a solution of alum and galls; it is steeped in lime-water; it is boiled in a solution of madder; it is washed, cleaned, and dried; it is again steeped in alum and galls, and again boiled with madder; it is boiled for many hours with soap and pearlash; it is boiled a second and a third time, with some additional ingredients; it is exposed to the fresh air for some time; it is boiled in water containing bran; and finally it is dried. Now every one of these manifold processes is the result of laborious investigations, which have cost much time, anxiety, and capital, although the resulting product may perchance be sold very cheaply. The dyer knows that if he once obtains a reputation for a beautiful dye, it may avail him for a sale of millions of yards; and he therefore scruples not to devote his best attention to that which may make its appearance even in a cotton handkerchief sold for a few pence. The above-named processes for Turkey red are those adopted in France; the Lancashire and Glasgow dyers adopt various modifications in one or other of the manipulations. It is said that this rich tint owes more to the dyers than to the chemists; the dyers have discovered it by a series of attempts, while the chemists are yet at fault concerning the rationale of the several effects produced.

From the dyer to the calico-printer is but a step. Few persons at the present day, knowing to how extraordinary a degree the business of calico-print-

ing is carried on in the north, would suspect that it was first practised (so far as England is concerned) in and near London. At Richmond, at Merton, at Crayford, and a few other places, these processes were conducted before Lancashire had directed its energies to the subject; but it was not to be supposed that cheap labour, cheap steam, and the vicinity of the cotton manufacture, would do otherwise than attract the calico-printing operations towards that busy county. The founder of the now distinguished family of Peel may be considered the founder of Lancashire calico-printing. Whether 'Peel's parsley leaf' is yet in existence as a pattern for cotton dress goods, we do not know; but it would be a curious memento of the progress of the art; for some of the members of the first Sir Robert Peel's family are said to have perfected the first printed specimens of this pattern, with the aid of the domestic flat-iron, on the domestic ironing-board.

The higher class of printed goods at the present day comprises barège shawls, printed velvets, printed flannels, and the more costly varieties of printed muslins. Great artistic skill is shown in devising the designs, mechanical skill in preparing the blocks, chemical skill in selecting the colours, and manipulative skill in the printing. All the cheaper printed cottons are now printed by the cylinder-process. The pattern is engraved on the surface of a copper cylinder; and by an admirable adjustment of mechanism this cylinder feeds itself with colour, cleans itself from superfluous colour, draws in the cloth to be printed, and effects the printing. Every colour requires a separate cylinder; so that for the more complicated patterns the cylinder-machine is really a very fine example of engineering, irrespective of the beautiful chemical results which it aids in producing. But for the more costly and delicate goods, such as the shawls and velvets above noticed, the original block method is still adhered to. In this method each colour has a block for itself, on which a certain portion of the pattern is cut or engraved; and the blocks are used singly and by hand, each printing as much as its size and its colour will permit. Where the whole design is but a repetition of one small pattern, the whole surface of the cloth is printed by a succession of applications of the same two or three blocks; but where a large shawl (for example) displays a design which is *not* merely a repetition of small bits of pattern, the number of blocks often becomes multiplied in an extraordinary degree. One of the exquisite barège shawls recently produced is said to have required more than five hundred carved blocks to produce it, every one of which represents a different part of the device (either in colour or in pattern) from any of the others. It is the mode of weaving that gives to these shawls the title of barège; the material may be silk or wool, or a mixture of the two, or a mixture of either one with cotton—according to the price; but the printer's art has enabled him to impart beautiful printed designs to all the varieties.

## The Chemistry of Porcelain.

From the dyer and the calico-printer we will turn to the manufacturer of porcelain and pottery.

Nearly all nations have applied themselves, in a greater or less degree, to the potter's art. If we look to the tribes of central and western Africa, we there find rough and unglazed pottery, often baked in the sun; and such may also be said of semi-civilised nations all over the world. In India and Japan more neatness and ingenuity are displayed. In China, as is well

known, fine porcelain was produced centuries before anything of the kind was known in Europe. In southern Europe, the oil-jars and wine-jars are the chief varieties of native pottery, the higher kinds of earthenware and porcelain being derived from other countries. At Sèvres, Meissen, Berlin, Vienna, and Copenhagen, royal encouragement by the governments of France, Saxony, Prussia, Austria, and Denmark, has led to the formation of establishments in which enamelled and gilt porcelain is produced in great beauty and variety. Holland produces a homely delft or earthenware, fitted for the steady homely Hollanders. But it is in our own country that the greatest variety exhibits itself; from the exquisite porcelain, which we owe to the skill of the Copelands, Mintons, Chamberlains, and others, down to the coarse red flower-pot, every kind is produced in England; and in the middle portion of the series—that which comprises the cheap but well-made and neat white and blue-and-white earthenware—we confessedly take the lead of the world.

Strictly speaking, the chemistry of the potter's art is not very extensive; it is rather to a *mixture* than to a chemical combination of the ingredients that pottery is due. In the finer kinds, however, where the clay undergoes a kind of vitrification, a chemical change really takes place, for the substance becomes semi-transparent. The china clay, produced from granite, and forming the body of our porcelain; the china stone, also the result of the disintegration of granite, used for glazing porcelain; the clays necessary for producing white earthenware; and the commoner clays for the various sorts of brown and stone ware—all are met with in this country. The discovery of the proper materials for English porcelain was quite a curious episode in the history of the pottery art. The peculiar clay used in China for this purpose is called *kaolin;* M. D'Entrecolles, who visited China in the last century, sent home a few specimens of this kaolin; and Mr. Cookworthy, of Plymouth, found on examination that it was identical with a very fine clay which he had seen near Helston, in Cornwall. It was nearly a century ago that this discovery was made; and from that day the English porcelain manufacture may date its commencement—though many struggles had to be borne before success attended the enterprise. This fine china clay differs from other clays chiefly in having a percentage of the very rare earth called *lithia;* all alike contain about two-thirds of their weight of *silica* or flint. At St. Austle and other parts of Cornwall, in the summer months, busy operations are being carried on, by which the quartz and mica are washed out of the clay (they having formed part of the granite which by disintegration constitutes Cornish clay), and the pure kaolin or porcelain clay is left behind. It is supposed that at the present time not less than twenty thousand tons of clay are annually shipped from Devon and Cornwall to the pottery districts—so enormous is the manufacture of porcelain. It must be borne in mind, however, that the clay is not *all* so employed; there is much demand for it by the paper-makers and the calico-printers, who employ it as a stiffening material—perchance to make things appear better than they really are. These statements relate to the carefully-prepared clay for fine porcelain; a much greater weight of commoner clay is sent from those two counties to the Staffordshire potteries.

One of the most pleasing advancements in the potter's art is that which has led to the production of the beautiful statuettes now so extensively known. It is not wholly a modern phase of the art, but within the last few years it has reached its highest degree of excellence. The great

firm of Messrs. Copeland was, we believe, the first to introduce, about 1842, that delicate variety of porcelain to which the name of *Parian* is given; and from that time may be dated what we will call the *sculpturesque* period of English pottery. Some call the material Parian, some call it Carrara; but be it called what it may, it very successfully imitates the more delicate kinds of marble employed in statuary. Gods and goddesses, nymphs and graces, satyrs, heroes, vases, urns—all are produced in this material, generally in miniature dimensions. The names of some of our best sculptors are now to be seen associated with graceful productions in this material—mind infused into clay. We must not, however, estimate this branch of art too highly. It is not really more sculpturesque in the mode of production than humbler departments of the art. The sculptor supplies a model; the moulder is very careful in preparing a mould from this model; the ingredients are combined with more than usual care; and the casting, baking, and subsequent processes are all sedulously attended to; but still it is not less a manufacture, in its details, than the production of plates and cups and dishes. Of the ingredients of this Parian nearly two-thirds are silica or flint, about one-third is alumina or clay, and the small remainder is made up of minute portions of soda, potash, lime, magnesia, and iron. All that careful pounding, calcining, grinding, sifting, mixing, boiling, evaporating, and kneading can do, to bring these ingredients into a perfectly fine and smooth state, is done, and all that the moulder's skill can effect is duly brought to bear on the perfection of the moulds. The Parian is not used in the state of clay, but as a liquid, analogous to the state in which plaster of Paris is employed in making casts. The creamy mixture is poured into the mould; some of it solidifies, and the rest is poured off; the solidified portion is baked until it assumes a firmness of texture; the mould is taken to pieces and the cast liberated; and all crudities of surface are removed.

But this is only a part, and the less artistic part, of what is to be done; formidable difficulties yet remain. A 'Dorothea' or an 'Ariadne' cannot be extricated whole from one single mould; the head, the limbs, the drapery, have so many curves and undulations of form, that only a small part can be yielded by one mould. Some of the groups recently produced have required as many as fifty moulds. Then comes the difficulty—the building up of a graceful form from many moulded fragments; the Parian artist is the Frankenstein of his art. The pieces have to be cemented together, and the joinings so obliterated that their existence can hardly be traced. There is a further source of embarrassment; the drying of the Parian makes it shrink to a remarkable degree; and unless great nicety be observed in the proportions of the several parts, and in the drying processes, the portions may not fit well together when all are ready. A 'Venus' with one leg shorter than the other, or the 'Graces' with crooked shoulders, or a 'Una' too big for the lion on which she is seated, might be awkward results of any failure of accuracy in these particulars. And it is not merely in putting these pieces together that great care is required; but also in the subsequent drying and firing. Let the goddess be ever so well shaped when her component limbs are set in their places, yet the slightest want of caution in adjusting it in the annealing oven may occasion a twist or bend which would render her a deformed goddess from that moment.

Such, then, is the mode in which the beautiful Parian statuettes are produced. Within the last few months a large number of such productions have met the public view, illustrating the talents of Bell, Gibson, Marochetti,

Danneker, Westmacott, Cellini, Foley, Thorneycroft, Canova, Townshend, Power, Marshall, &c., on the one hand; and those of Minton, Copeland, Chamberlain, Rose, Wedgwood, Ridgway, &c., on the other.

The terra-cottas, another example of the application of pottery to fine-art purposes, are decidedly more clay-like in their character; they make no pretensions to the porcelain-like texture of Parian; but yet they are susceptible of very wide application. The clays are carefully selected, the moulds are wrought by a man of taste, the mixing and pressing are effected with judgment, and the firing is also well managed; the resulting terra-cotta ('baked clay') then becomes a very advantageous decorative material for the architect's use. The entire external ornaments of a church near Bolton are made of terra-cotta.

And what is said of terra-cotta may be said nearly as much of the now-important manufacture of encaustic tiles or tesselated pavements. The clays are selected with care, and all the manufacturing processes are sedulously managed. There are two additional features here—that the material is used partly as a clay to be *pressed* into moulds, and partly as a cream to be *poured* into moulds; and that the materials have brilliant colours imparted to them by the admixture of metallic oxides.

There is perhaps more chemistry in the glazing, the painting, and the gilding of the potter's productions than in the earlier stages of manufacture. The glazing is truly a coating of glass; and the problem has been to discover a mixture which, if applied as a liquid, may be baked into the state of a solid glass. Salt and lead are known to be two of the ingredients employed; but manufacturers have others which they wish to keep secret, each for himself. Be the ingredients what they may, they are made into a liquid, in which the cup or other article is dipped; and the heat of a 'glaze-oven' converts this liquid into the beautiful and durable glassy envelope with which we are so familiar on our table-ware. In the painting and gilding of the more costly specimens, nearly all the colours employed are metallic oxides, mixed to the proper consistency with turpentine and various kinds of oils and spirits. When applied to the ware, these colours appear dull and dingy; but the heat of the 'enamel-kiln' not only burns the colours indelibly into the ware, but developes very brilliant tints. Great is the attention necessary in this firing; for if the degree of heat and the length of its continuance be either more or less than a due medium, the colour fails in its development, and perhaps also fails in its due fixity. The porcelain-painter and the glass-stainer are equally dependent on the chemistry of heated metallic colours.

The chemistry of cement is a curious one; for the stony particles adhere with a force which is in some instances almost equal to the power of stone itself. The so-called Roman cement has long been famous for its cohesive property; but the Portland cement recently introduced far excels it. In an experiment lately conducted, two solid blocks were prepared, one of Roman and the other of Portland cement; and they were placed in such positions that weights might be suspended from them. The Roman cement yielded to a disruptive force of eleven hundred pounds, but the Portland cement stoutly maintained its integrity till rent asunder by a weight of nineteen hundred. But this cement has still more strikingly shown its strength when used as a mortar in brickwork. On a recent occasion, in Hyde Park, a brick beam was built up with Portland cement as a mortar. The bricks were hollow, and were so ranged as to form a beam about four feet in height by two in width. This beam was rested at the two ends on supports more than twenty feet

asunder, and weights were suspended from the centre; and not until the astonishing weight of nearly seventy thousand pounds was thus applied did the beam yield and break. It was not the actual binding power of the cement alone that resisted this enormous force, for thin slips of iron were introduced at different parts; but the experiment was intended to show how much strength might be obtained by hollow bricks and Portland cement, aided by a little iron.

The production of 'artificial stone,' now employed for many building and decorative purposes, has in it something of a more chemical character than that of cement; for flint is actually dissolved to enable it to combine with other substances.

### What we owe to our Salt-Mines and Alum-Pits.

The chemistry of our invaluable salt district is not so noteworthy for the processes by which the salt is brought into marketable form, as for those which the salt itself subserves in the manufacture of chemicals and drugs. Yet is the Cheshire routine of operations very interesting. Beneath the valleys of the Weaver and its tributary streams are those vast saline treasures which seem as if they would be inexhaustible. There are near Northwich two beds of hard dirty-looking rock salt, one at a depth of about three hundred feet, and one much nearer the surface; the beds are very little less than a hundred feet in thickness, and have each an area of about a square mile. The contents, therefore, of the Northwich beds can be approximately calculated. There are nearly twenty mines there, from which the salt is obtained by a series of operations nearly analogous to those of coal-mining, and in quantity amounting to sixty or seventy thousand tons annually. But this is not the salt with which we are familiar; it is nearly all exported. Our well-known and precious table-salt is obtained almost entirely from brine-springs, which form in unknown quantities beneath the ground, by water flowing over salt-beds of unknown dimensions. Pumps, well applied, never fail to draw up this strongly saline liquor; it is pumped by steam-engines into vast reservoirs, from which pipes convey it to shallow iron evaporating pans, where heat causes the water to evaporate and the salt to crystallise. There are evaporating houses in Cheshire which exceed even the Crystal Palace in length, and in which a thousand tons of salt can be produced in a week. These brine-springs yield prodigious quantities; it is said that the Cheshire produce has now reached nearly half a million tons annually.

In tracing the manufacturing uses of salt, we may observe that it is really little less than impossible to follow out correctly the steps by which valuable chemicals result from the production of other chemicals. Almost all chemical transformations result from a play of affinities. A will combine with B, but it has a still stronger liking for C; while B has a more energetic affinity for D than for A: if these four elements get together, they busily readjust their connections; their former states of combination will very probably be overthrown, and we shall have two resultant compounds, AC and BD. Among many chains of processes, let us take one particular chain as exhibited in the great chemical works of the north, in connection with the use of salt, and see how curious are the gradual developments of new compounds.

We begin with sulphur—the crude yellow brimstone which is brought in such large quantities from Sicily, and is also one of the residual products of our copper-smelting works. It is put into a furnace and burnt away—form-

ing sulphurous acid gas by its combination with the oxygen of the atmosphere. The gas is collected in leaden chambers, some of which are so vast as to have a capacity of a hundred thousand cubic feet; and in these chambers it is made to combine with a little more oxygen and then with water, whence results liquid sulphuric acid—the well-known but strangely-named oil of vitriol. This hot burning acid, produced from tasteless sulphur and salubrious oxygen, is heated in a furnace with common salt; and one of the consequences is that muriatic acid gas is driven out of the salt. This acid, mixed with water, and allowed to trickle upon common chalk, will produce carbonic acid gas in great abundance—either for making soda-water or for any other purposes. Muriatic acid, too, if heated carefully in a stone vessel with oxide of manganese, gives up its chlorine in the form of a gas; and this chlorine, if admitted to a chamber in which slaked lime is placed upon shelves, converts this lime into chloride of lime or *bleaching powder*—a substance which has created quite a revolution in bleaching and dyeing processes.

But we must now go back to the point at which the muriatic acid was separated from the salt. The sulphuric acid cannot drive the muriatic acid out of the salt without being itself brought within the range of affinities; the granular salt becomes a pasty sulphate of soda. A little coal and a little chalk are added, and another action of affinities commences, which settles down into the production of carbonate of soda and sulphuret of calcium. Carbonate of soda is that invaluable form of soda which is now used to so enormous an extent in glass-making, soap-making, bleaching, washing, and other operations. When another dose of carbonic acid gas is given to this carbonate of soda, it becomes bi-carbonate, the nice-looking white powder which forms an essential ingredient in soda-water and ginger-beer powders.

Thus, then, we see how extraordinary is the production of valuable chemicals from the decomposition and recomposition of some of the cheapest and most familiar of substances. Brimstone, salt, coal, chalk—nothing very beautiful or costly about them; and yet with a little aid from other substances, we find them yielding sulphuric acid, muriatic acid, carbonic acid, chlorine, bleaching-powder, soda-water powder, and carbonate of soda. There is one thing which chemistry has not yet done in the matter, but which it must do before this beautiful train of processes can be considered complete; it must discover some use for an earthy substance called sulphuret of calcium. In the production of the carbonate of soda, although sulphuric acid and chalk are required as agents, to bring about changes by the play of affinities, yet the sulphur of the one and the calcium of the other form no component parts of the carbonate of soda itself, the resultant of the process; they constitute a solid refuse which is a sad burden to the manufacturers. This refuse or waste is sulphuret of calcium; no means have yet been devised of making it profitably available; it cannot be ignored; it must not be thrown into rivers or canals; it is a 'great fact,' which has necessitated the purchase of acres upon acres of land, upon which the refuse is thrown up in huge heaps as high as a moderate house, and with a bulk of many hundred thousand cubic feet. When we find that every fraction of the refuse from gas-works has been rendered serviceable for some purpose or other, we must not doubt that chemistry will by-and-by do something with these monster heaps at the soda factories.

As salt has its chemical notabilities, so has *alum*. In truth, the chemistry of this substance has not a little that is remarkable about it. The three very

dissimilar substances—sulphuric acid, clay, and potash—combine to form it: and when so combined, its scientific name becomes 'sulphate of alumina and potash.' For many ages it was produced chiefly from a particular kind of earth or ore; but modern ingenuity has devised a mode of preparing it by a direct union of the materials. Let us briefly glance at both methods.

In many countries there are strata of alum-stone or alum-slate, which will yield alum by proper treatment. There is a thin layer of alum-stone between layers of coal and lime; and when the coal has been removed by mining, the alum-stone becomes gradually so acted upon by the atmosphere as to become disintegrated and powdery. But whether stony or powdery it is all brought up to the surface, as it contains sulphuric acid and alumina—two of the ingredients for alum. The stony portion is made to yield to fire, instead of air and moisture; it is built up into huge pyramidal heaps, and there fired until brought to a state of disintegration. Then do the processes of steeping and boiling and crystallising take away from the alum that which it does not want (iron), and impart to it that which it needs (potash); the potash being added just before the crystallisation. The alum-maker obtains an additional product, too, beyond his alum; for the iron which forms part of the alum-stone he contrives to separate, and to convert into beautiful green crystals of copperas —so surely does any complicated chemical process lead to the production of substances besides that which is the immediate object in view.

But the Newcastle chemists have devised a mode of making alum independently of the aid of alum-stone. Give them sulphuric acid, clay, and potash, and they will return you a mass of crystalline alum as the resulting product—not among the least of the curiosities of chemistry. Cornish clay, calcined and ground very carefully, is mixed with sulphuric acid; the two boil up together furiously, without any heat being applied (another of the 'curiosities'); water is added; and after a time for subsidence, the liquid is pumped into another vessel, where potash is added to it. Crystallising, and steaming, and re-crystallising then convert this liquid into a solid mass of alum—ready for any of the purposes which it is fitted to subserve in the arts. When the crystallisation takes place in a very large vessel, and the staves of the vessel are pulled asunder to liberate the solidified alum (a frequent practice) the appearance of the huge mass is really magnificent, especially if we look at the brilliant radiating crystals in the interior cavity. One of the many striking results of these combinations shows itself in this manufacture. Alum is the product sought for, but *Prussian blue* is also obtained in immense quantity; the clay employed contains some iron, which must be got rid of in some way or other; and it is finally driven out in that form which constitutes the beautiful Prussian blue.

It is one of the grand feats of chemistry that—every now and then—it gives commercial value to materials hitherto useless: converts into a boon that which has been a burden. There is an example in point, connected with our present subject. Around our numerous collieries are huge heaps of a slaty substance called *shale*, which forms the material of the interlying beds between the seams of coal; it is removed when the coal is mined, and is a perpetual source of annoyance to the coal-owners, who do not know where to put it or what to do with it. How great would be the advantage, then, of any project which might bring this shale into use! So thought Mr. Spence, of Manchester, who formed a plan, about seven years ago, for producing alum from the shale; he adds one annoying refuse (gas-works' waste liquor) to another annoying refuse (shale from coal-mines), and from the two, by various

chemical processes, he produces alum, copperas, and sulphuric acid. M. Robin exhibits few marvels more 'mystérieuses' than those which chemistry often achieves; and what is more to the purpose, these chemical marvels have a most potent influence on the well-being of the world in general.

Another interesting fact in connection with the recent manufacturing history of alum is, that dyers and calico-printers are now beginning to use only the *essential* parts of it, rejecting those which have no mordant quality. Alum is a sulphate of alumina, with one or other of the three alkalies, potash, soda, or ammonia; but chemists now know that the alkali simply causes the alum to crystallise, without adding to its mordant power. The dyers say, "we care not about the crystalline structure, give us the mordant;" and forthwith the manufacturing chemists of Newcastle devised a way to produce slabs or blocks of opaque sulphate of alumina, which—though neither crystalline nor beautiful—have all the potency for which alum is valued.

## The Chemistry of Fermented Drinks.

There is perhaps no department of manufacturing chemistry marked by more interesting circumstances than that which comprises the production of fermented liquids. The wonders of organic chemistry are many, and some of them are made manifest in this department. Different as we may consider the general vegetable structure of corn, sugar-cane, fruit, beet-root, and potato, they may all be employed as sources whence to obtain alcohol or spirit; different as are spirit, beer, vinegar, and quartern loaves, they may all be obtained from the same corn; and different as are wine, beer, cider, malt, sugar, and molasses, vinegar may be obtained from any or all of them.

It is a curious stage in the chemistry of this subject, that *sugar* must be developed before any of the fermented drinks can be produced; indeed, sugar is the substance which undergoes the fermentation.

In the first place, then, sugar is a very abundant component part of vegetable substances. It is found in the sugar-cane, in the maple, in beet-root, in carrots and turnips, in potatoes and parsneps, in grapes and fruits of all kinds, in manna, in liquorice, in mushrooms, in every kind of grain—indeed it is one of the most generally diffused of vegetable principles. Practically, the sugar-cane is the source whence the sugar of commerce is most readily obtained. How the canes grow in tropical countries; how the 'slave-question' is mixed up with everything relating to the commerce in these canes; how the canes are cut when ripe—these are questions which precede what we may term the chemistry of the subject. The canes are rich in juice, a sweet but crude liquid; this is expressed from them by the crushing force of ponderous rollers, and trickles into a cistern beneath. Then, to prevent an acidifying process, the juice is at once boiled rapidly, the impurities removed from the surface, the watery portion evaporated, and the rest brought to the state of a thick syrup. A hundred average sugar-canes will yield about five gallons of juice, from which six pounds of crystallised sugar result. The syrup is cooled in shallow vessels, and then packed in hogsheads. The drainings or molasses from the syrup are fermented to yield rum, and the granulated sugar in the hogsheads forms our 'moist' or 'brown' sugar. Then, when brought to England, the sugar is either sold in the imported state, or is chemically treated to form 'white' sugar. In the latter case it has to pass through strange ordeals. Melted in hot water, strained through canvas bags to get rid of the impurities, filtered through pounded charcoal to dissipate colour,

boiled *in vacuo* to drive off much of the water, granulated to prepare for crystallisation, crystallised to separate the treacle—all these are processes through which the sugar must pass in its transformation from brown 'moist' to white 'lump,' and in which many curious processes are involved.

One of the novelties in this sugar-chemistry is connected with beet-root. Sugar has been prepared from this useful vegetable for many years past in France and Germany; and hopes are now entertained respecting it as a panacea for poor Ireland. A hundred and fifty thousand tons of beet-root sugar are now said to be made annually on the Continent; and as Ireland grows the beet favourably, an attempt is being made to establish this manufacture there. A factory has been built at Mountmellick, in Queen's County, with a subsidiary establishment for cutting and drying the beet. The factory can operate on 300 tons of beet per week, supposing a supply to be obtainable. The roots are gathered, cut, topped and tailed, washed, and rasped into pulp; the pulp is pressed to yield the juice; the juice is boiled, purified with lime-water, evaporated, boiled *in vacuo*, and crystallised. Perhaps we may yet see the day when the beet-root will benefit the sister island.

As sugar exists in so many vegetables, so must there be sugar in all the substances which yield fermented drinks; and the mode of compelling this sugar to render up its properties is full of chemical niceties.

Let us see what results when beer or ale, porter or stout, is to be produced. Any kind of corn will yield beer; because the starch contained in a grain of corn is convertible into sugar, and the sugar into a fermentable substance. But by the process of *malting* (in which moisture and heat are applied to barley) the starch of the grain is converted into sugar in such a state as greatly to facilitate the brewing process. Malt, therefore, or malted grain, is employed by our brewers. The malt is crushed between steel rollers to a powder, or rather grist (we are speaking of the operations at the great porter breweries); it is mashed with hot water to extract the saccharine matter from it; the extract is boiled in huge coppers with the flowers of the hop, to impart bitterness; the extract or 'wort' is cooled, then fermented in vessels of an enormous size, then 'worked' or deprived of its frothy yeast, and then fined or cleared. The chemistry of brewing is placed in an interesting light by the recent declaration of the Burton ale-brewers (made under circumstances which enforce belief), that the high-class Burton ale is made from no other ingredients whatever than malt, hops, and pure water.

But the spirit or alcohol of the distiller is more chemically important than the ale or beer of the brewer; since it passes through more advanced stages of progress. Brandy is produced from wine, rum from molasses, whiskey and gin from corn; they are all alike, however, in owing their fundamental quality to the alcohol which they contain. Each country employs the saccharine material most readily obtained; and thus the flavour of different kinds of alcoholic beverage depends on local circumstances of soil and climate. The wine-regions of France have in the grape an abundant supply of sweet juice which yields spirit by distillation; the sugar-planters of the West Indies have a thick sweet residue from their sugar-drainings which is rich in alcoholic elements; and corn-growing countries have in store the starchy supplies which become transformed first into sugar and then into spirit. The *differences* between brandy, rum, and whiskey depend on the differences between grapes, sugar-canes, and corn; the *resemblances* depend on the alcohol which they are all in common capable of yielding.

So far as our own English-made spirits are concerned, they can be pro-

cured either from raw grain or from malted grain. Some distillers employ malt only, but as this is very costly, raw grain is usually employed in larger quantity—barley, chiefly; but also wheat, rye, and oats; it is a question of £. *s*. *d*. with the distiller, at any particular time and place, to combine his ingredients according to the state of the market. These ingredients, then, are regularly *brewed* before they can be distilled; the saccharine matter must be extracted and fermented before alcohol can be obtained. The malt is crushed, the grain is ground, the water is heated, and all three are mashed up together in a mash-tun; the sickly-sweet extract or 'wort' that results is cooled and then fermented, by which the sugar of the grain becomes converted into alcohol. To separate this alcohol from the water is the object of distilling; the fermented liquor or 'wash' is boiled in close stills; and the alcohol, becoming vaporised sooner than water, passes out of the still in a vaporic form, and is then condensed into liquid spirit by the vicinity of cold water. Real good whiskey is much more scientifically pure (so to speak) than any kind of gin or cordials; the latter are 'doctored' in various mysterious and questionable ways.

As spirit is an advance upon beer, so is vinegar an advance upon spirit, in respect to the chemical history of the liquid produced. It may be made from any of the substances which will produce beer, or from any which will produce spirit, or from beer and spirit themselves; but it goes one stage beyond them in the chemistry of its manufacture. Various sources are employed by different vinegar makers, but malt is more generally used by the manufacturers in the neighbourhood of the metropolis. It would be a sore complaint to make against the usquebaugh of Ireland, or the 'mountain-dew' of the Highlands, that it was sour or acid; and yet these burning liquids are produced from the very same kind of malt as the greater part of the London vinegar. The vinegar-maker grinds his malt into grist; he extracts 'wort' from this grist by mashing; he cools the wort in a refrigerator; he ferments the wort into *gyle* (a distiller would call the liquor *wash*, while to a brewer it would be simply unfinished *beer* or *ale*); he transfers the gyle into casks; and he there causes it to undergo the acetous fermentation which converts it into vinegar. This acetous change is very remarkable, for it may be brought about either by the heat of a closed room or by the fresh air of a field. In France the stoving is most practised, and it is gradually becoming extended in England; since the field-method, by leaving the liquid many weeks or even months in the casks, renders much capital unproductive throughout this period.

In all these processes—in the extraction of juice from the sugar-cane, in the preparation of brown sugar from the juice, in the refining of this brown sugar into white, in the production of beer and ale, in the distillation of the various kinds of spirit, in the making of vinegar—the recent improvements have been so many and varied, that we cannot even enumerate them. The niceties of chemistry have, one by one, been rendered available, either for the improvement of the liquid produced, or for the economy of the materials employed.

Wine-making has also its chemistry, though not to so notable an extent as the examples just adduced. Take the case of ordinary sherry, for instance. The fine Spanish grapes are gathered in September, when fully ripe; they are sorted, turned, and exposed to the sun for a couple of days; they are placed in a shallow trough, and are jumped upon in an uncouth manner by men wearing wooden shoes. The bruised grapes are subjected to the action

of a wooden press, by which the *must* or juice is pressed out; and this must, received into proper vessels, is allowed to ferment into wine. The great point of difference between wine and the other fermented drinks is, that the former gains very greatly in quality by keeping; the fermented juice contains many more substances than merely alcohol and sugar; and these substances acquire by age many attributes which the connoisseur knows well how to appreciate. Why 'fine old crusted port, twenty years in bottle,' is different from new port, vegetable chemistry must tell us. Wine-making is not a steam-engine process; it is an old-fashioned operation of old-fashioned countries, and is but little subject to change or improvement.

### Chemical Miscellanies.

We will group together a number of miscellaneous examples which present curious or novel aspects.

The boracic acid lagoons of Tuscany afford a notable example of a dreary desolating natural phenomenon being made available to man's use by the aid of chemistry. In a mountainous district about twenty miles from Sienna there is a fearful region. Bare and bleak mountains are immersed in clouds of thick sulphurous vapour; boiling hot water bursts from the ground with explosive noise, giving off abundance of smoke and vapour; miniature eruptions frequently occur in the ground, producing dismal hollow reverberating noises; the heat is close and suffocating; the surface of the ground is covered with much crystalline and efflorescent matter; and there are lagoons or ponds containing liquid of such a dread character that no living thing can bear immersion in it for an instant. The water of these lagoons has been found by modern chemists to contain boracic acid; and hence it became an object to try whether the useful substance *borax* could thence be obtained. The quantity of the acid in the water is not large; but it is known that the vapours which curl about the mountains include boracic acid vapour; and a happy mode has been suggested of making these vapours useful instead of deleterious to mankind. Artificial cavities are formed at various heights in the mountains, which become gradually filled with water by the mountain streams; the hot vapours which burst from the ground, in the beds of these cavities, combine with the water, and convert it into a kind of weak boracic acid; and this acid, by concentration and crystallisation, produces borax. It is awful work, however: an accidental fall into one of the lagoons is almost certain death.

Nothing can be more curious and instructive, in connection with manufactures, than the contrast between the sources whence chemical substances are obtained, and the purposes to which those same substances are appropriated. Acids, alkalies, salts—all exhibit these contrasts. We have noticed many such examples; let us glance at a few more.

Let *tartaric acid* be an instance. This acid is obtained from the 'tartar' (as it is familiarly called) which is deposited in wine-vats during fermentation, and which is subjected to melting and crystallising and other processes to make it yield up the acid. Many thousand tons are procured annually from France, Spain, Italy, and other wine-producing countries; and when the beautiful acid crystals are derived by chemical aid from the tartar, they are employed in calico-printing, and in the preparation of lemonade and other cooling beverages. White wines and red wines yield two different kinds of tartar, similarly designated as white and red; and according to the mode of

treatment, in the manufactories near London, either *cream of tartar* or *tartaric acid* is produced from the crude tartar. Another acid, the *citric*, is obtained from lemons, and is applied to numerous purposes, including some nearly identical to those for which tartaric acid is fitted. The concentrated juice of the fruit is subjected to various crystallising and other processes.

Oxalic acid, gallic acid, benzoic acid—all are crystalline, and all are obtained from animal or vegetable substances. It seems strange to those unfamiliar with chemistry that such a substance as oxalic acid—crystalline in form and poisonous in quality—should be derived from such heterogeneous sources as sugar, silk, saw-dust, hair, and glue—substances notably unlike each other. The fact is, however, that there are certain chemical elements in each of them which may be separated by various processes, and made so to recombine as to form oxalic acid; for this acid consists of nothing but oxygen, carbon, and water. The sorrel which school-boys pick in the fields derives its sourness from the presence of this acid. In manufactures and various processes it has something of a bleaching action; for it is used by calico-printers for 'discharging' colours from cloth; and it is also employed for whitening boot-tops, straw bonnets, and other articles. Gallic acid, another of the three mentioned above, is prepared from nut-galls; it forms a chief ingredient in writing-ink, which in part owes its blackness to this acid. Benzoic acid is produced from a gum or resin called benzoin—or, in more popular language, *benjamin;* it is the juice of a tree growing in tropical climates, and has a very agreeable fragrance.

There are many other acids employed in manufactures or in medicine, the sources of which are very remarkable. Thus the much-dreaded *arsenic*, or arsenious acid, is derived largely from the tin-mines of Cornwall; the metal arsenic is combined with most ores of tin, and in the process of roasting the ore the arsenic is separated in the form of arsenious acid or white arsenic.

Nor are the salts less worthy of attention in respect to the sources whence they are obtained. These salts are generally compounds of acids with alkalies, earths, or metallic oxides. Take the muriate of ammonia, or sal-ammoniac, as an example. The first information which chemists had respecting this salt was that it came from Egypt. It is well known that the sandy districts of that country are very deficient in fuel; the inhabitants have to tax their ingenuity to find a substitute; and one such substitute is dried camels' dung, which gives a dull smouldering kind of fire. The soot or 'blacks' which rises from this fuel is found to contain much muriate of ammonia; and means are adopted for extricating this salt from the soot. These means, as adopted by the Egyptians, are singularly rude and primitive, and were not likely to maintain ground (so far as the supply of Europe is concerned) after chemistry made its recent gigantic strides. Ammonia, in one or other of its combinations, is now known to be present in a number of animal substances, such as silk, hair, and wool—bone, blood, and flesh—horn, hoof, and claws; and the carcases of slaughtered animals supply an abundance of such substances at a very cheap rate. Modern chemistry is the most universal and the most useful of all scavengers; it collects refuse from every possible quarter, and extracts value and beauty from it. A horse's hoof, or an ox horn, is quite a treasure to the chemist; he will utterly destroy it so far as form and component structure are concerned; but look at the glittering crystals, and the brilliant colours, and the useful acids and salts, which he will obtain by the transformation. The gas-works, too, which are obliged to use liquids to wash and purify the gas, would be burthened with an

unsavoury ammoniacal liquor, were it not that the chemist kindly steps in and uses this liquor as a source whence to obtain sal-ammoniac.

The nitre which forms such a notable ingredient in gunpowder is another of those salts which occur in queer and out-of-the-way places. That the walls of stables and cellars, the sides of caverns, and the surface of the ground in hot climates, should yield nitre in a fine powdery state seems somewhat strange; yet such is the case, and a large portion of the commercial supply is thus obtained. In some of the tropical regions of Africa and Asia nitre forms on the ground as a white efflorescence, when heavy rains have been succeeded by intense heat: the rain first acts on certain constituents of the soil, and the heat then developes the nitre as a chemical resultant. The natives scrape off an inch or two in depth of the soil, steep it in water so as to wash out the nitre, allow the earthy matter to subside, expose the nitreous liquor in shallow vessels to the heat of the sun, and evaporate it so as to produce crude coarse nitre. In other countries of the East the nitre is scraped annually from the walls of caverns, and treated nearly in a similar way.

Like as in the case of sal-ammoniac, so in the present case, modern chemistry has found the means of producing the compound from sources independent of any particular localities. A little nitre is contained in tobacco, maize, beet-root, and other plants, but not in sufficient quantity for manufacturing purposes. By making, however, a sort of artificial nitre-ground, or a bed containing nitreous materials, the formation of nitre is ensured at any convenient spot. Stable dung, vegetable mould, wood ashes, and other substances which contain either nitrogen or potash, are worked up into a sort of clay and built into beds or heaps, the slow action on which by the atmosphere leads ultimately to the production of nitrate of potash, the chemical name for nitre.

The bones that used to be thrown away, unless sufficiently large and good for the purposes of the turner, are now sedulously preserved. Either the mill grinds them up into a powder for manure, or the chemist extracts phosphorus and other valuable matters from them. The soot and sweepings and sewage, which used so to perplex our forefathers, and which still perplex those who have been slow to avail themselves of modern discoveries, are precious stores to the chemist, whence he obtains products often of singular beauty and usefulness. Blood, lime, charcoal, and other substances used in the refining of sugar, were formerly consigned to the dust-heap or the common sewer when the refining was completed. Not so now, however; for the additions they have acquired in the process render them actually more valuable to the chemist than in their former pure state. Twenty years ago guano was utterly without value in the market; but agricultural chemistry has now given it such a value that hundreds of ships are employed in conveying it across the seas. The gas companies used to pay money for permission to throw away their refuse ammoniacal liquor into the common sewers; but chemistry, as we have just remarked, has created a profitable market for this liquid. The water in which fleeces are washed becomes impregnated with the greasy impurities with which the wool filaments are coated, and this water used to be thrown into ditches or drains; but now, by adding a little alkali to it, a kind of soap is produced which is available in the subsequent scouring operations in the woollen manufacture.

The chemical history of *congreves* or *lucifers* is by no means devoid of interest. The days of the flint and steel are passed, so far as England is con-

cerned; a tinder-box will become a curiosity in a few old-fashioned houses. The first attempts of chemistry in the matter were rather showy and laboured. There was the French method of obtaining light by means of the heat developed in compressed air, the compression being produced by a piston in a tube; there was the phosphorus bottle, and the sulphur match to act upon the phosphorus; there was the sulphuric acid bottle, with matches tipped with chlorate of potash; there was the platina bottle, with a complicated apparatus for producing and directing a stream of hydrogen gas on the platina. But all these have given way to the modern congreve—the very perfection of simplicity and usefulness and cheapness. Whether the composition with which the matches are tipped be one or another of the various mixtures now known to chemists, and whether they ignite noisily like lucifers or quietly like congreves, they all alike have the property of ignition simply by friction. All the matches have either phosphorus or chlorate of potash as one ingredient in the composition with which they are tipped. Of the splints or matches themselves we have said a few words in the sheet relating to Wood; and we may here add, that a witness, examined a few years ago before the Children's Employment Commissioners, stated that he used a thousand pounds' worth of American pine yearly in the making of lucifer-boxes. He stated his belief that from twelve to fifteen thousand gross were made every week in London; and as each box contains about fifty matches, the yearly produce of matches in London would thus amount to five thousand millions.

# STEAM-POWER AND WATER-POWER.

CONSIDERING that winds blow and streams run their course without man's agency, and without requiring any labour of mind or body on his part, it might seem that wind-power and water-power *ought* to be more efficient and economical than steam-power. Yet our modern engineers and manufacturers do not act as if such were the case: they are building their steam-mills in substitution of the old familiar wind-mills; and even in the valleys of Yorkshire and Lancashire, where running streams have furnished the motive power for water-wheels during many generations, steam-engines are multiplying rapidly, and are taking the place of the older machines.

The truth is, that

> "When the wind blows,
> Then the mill goes,"

—is not merely the assertion of a simple fact; it contains within itself a virtual admission of something else, viz., that when the wind does *not* blow, then the second line will fail—indeed, another couplet in the song propounds this important truth. Now mill-owners, in the present day, do not like to be dependent on a fickle or uncertain source of power; the steam-engine is an obedient servant, which will work where, when, and how its owner pleases—being nourished with proper steam-engine food; and these advantages overweigh those which might be supposed to render windmill-power cheaper than steam-power. Again, though a running stream will set in motion all the machinery of a large factory, yet a cessation to its flow, in seasons of drought, may throw all the economical arrangements into confusion; indeed, there are factories in the north in which it is found necessary to make special agreements between masters and men, as to wages being dependent on the continued supply of water-power.

It will probably ever remain true, however, that wind-power and water-power will have their ranges of usefulness, let steam advance as it may: and that steam-power will continue to be a mighty available agent, even if the sanguine expectations of some inventors be realised concerning electro-motive power. It is of immense advantage to be able to do things in more ways than one; since the best method is not always the most easily obtainable: and any other becomes temporarily the best if we have it at command when most wanted. There is one particular stage in most of our machinery, in which a wheel—call it a 'fly-wheel,' or by any other name—is made to rotate, and if this rotation be produced, the machinery will work throughout: the machine-owner has to determine whether a man's muscles, a current of wind, a flow of water, or a boiler of steam, shall turn the wheel; he may choose from all, for all are available in different degrees.

### The Ubiquity of the Steam-Engine.

It will be scarcely necessary, considering the limited object of the present paper, to say much concerning the mechanical details of the steam-engine; but a few words will suffice to show the leading facts which distinguish different *kinds* of engines.

Where steam is only required to press the piston in one direction (as in a steam-pump, in which the buckets are able to descend by their own weight), we have a *single-action engine;* but where steam is admitted both above and below the piston, for more efficient action, we have a *double-action engine.* In the *atmospheric engine*, displaced by Watt's improvements, the downward movement of the piston was caused by atmospheric pressure rather than by any gravitating weight; so that it formed a particular kind of single-action engine, but of less efficiency. When Watt supplied a separate condensing vessel to the atmospheric machine, he produced the *condensing engine.* Seeing that complex machinery, a water pump, an air pump, and a supply of cold water, are necessary for the condensing engine, the frequent difficulty of supplying these appendages led to the construction of the *high-pressure engine*, in which the piston is moved in one direction by the elastic power of the steam being greater than that of the atmosphere. But as high-pressure steam is also used in some condensing engines (the Cornish mining engines have sometimes steam of 50 lbs. pressure on the square inch, although built on the condensing principle), it is occasionally urged that all may be classed as *non-condensing, high-pressure condensing*, and *low-pressure condensing engines.* The 'low-pressure,' in England, is considered to imply an excess above atmospheric pressure of only a few pounds on the square inch; but in the United States it would still be deemed low-pressure unless it exceeded 20 lbs. per inch; in some of the Mississippi steam-boats the pressure reaches the dangerous pitch of 150 lbs. per inch—enough to blow up everything, on the slightest mishap. In *marine engines* the action may be condensing or not; in this country it is condensing, but not in America. In *locomotive engines* the action *cannot* be condensing, for there are no facilities for the ponderous condensing apparatus; they are therefore always high-pressure, amounting to 50 or 60 lbs. per square inch.

The *expansive engine*, or the steam-engine acting *expansively*, affords a beautiful example of the economy of power. In an ordinary steam cylinder the piston is urged onward by the simple *pressure* of the steam behind it, and not because the steam is elastic; the movement would similarly take place if water or any other substance pressed with equal force on the piston. But besides this there is an additional power due to the expansive tendency of steam; and engineers now save a portion of their steam by making the other portion bring its expansive tendency into action. If the cylinder be (say) only half filled with steam, the piston will be driven to the centre of the cylinder simply by pressure from behind; but then this steam will expand, by virtue of its elasticity, and in so expanding it will impel the piston further onward. The piston in such a case owes its motion to two forces—first the *pressure*, and then the *expansion* of the steam. When a steam-engine is said to be 'working expansively,' the supply of steam is cut off suddenly, so that the cylinder is only one-fourth, one-third, or some other aliquot part filled. The mechanism by which the steam is shut off at a given point is often exceedingly beautiful. The cases in which the expansive action becomes most

serviceable are those in which steam of high pressure or great density is employed.

We made a brief allusion to the *food* of a steam-engine. This food is a subject of much earnest inquiry to engineers, and is made the groundwork of many curious calculations. Just as a horse-owner places in different columns the value of the food eaten and of the work done, so does an engineer measure the efficiency of his dumb worker—the never-tiring ever-available steam-engine.

A bushel of coals is, to an engineer, a representative of a certain amount of 'power.' What this power is he cannot tell us; he only knows that it is a something which sets other somethings in motion: he cannot see it or describe it, but he can *measure* it accurately. As the perfection of machinery becomes more apparent, the 'power' elicited from a given quantity of fuel becomes greater and greater; the coal heats the water, the water changes into steam, the steam moves the piston, and the piston-movements act upon fly-wheels and so forth; and any improvement in any part of this series of operations is followed by an increase in the power obtained. The mode in which engineers estimate this power is curious; they reckon by the number of pounds' weight which the power would raise (by proper intervening mechanism) to a height of one foot—or (which is equivalent) the number of feet high to which one pound could be raised. In a well-managed Cornish mining steam-engine a bushel of coals will produce power enough to raise 80 or 90 millions of lbs. one foot high: and in some carefully-conducted experiments this number has been raised so high as 125 millions; this is called the *duty* of an engine—the number of millions of pounds' weight which a bushel of coals would enable it to raise to a height of one foot. In ordinary steam-engines for manufacturing purposes the fuel is never so scrupulously economised: and the 'duty' is here believed to be not more than 20 millions on an average. The *duty* of an engine refers, as here explained, to the ratio between the fuel consumed and the force produced; but the *power* of an engine relates to the space of time in which a given amount of force is exerted. Thus, 20 million lbs. raised one foot is the *duty* of an ordinary engine from a bushel of coals, but it is also the *power* of a 10 horse-power engine working for about one hour; in the former we reckon not the time consumed: in the latter we are equally regardless of fuel consumed. A 'horse-power' has ceased to be really significant; it now only indicates size of cylinder, for a '100 horse-power' engine now often possesses double the power of one similarly designated in the days of James Watt. To show the singular way in which sources of power are compared, it may be worth while to mention that the evaporation of one cubic foot of water into steam produces power about equal to that of one horse working one hour.

Neither height nor depth deters steam from its triumphant course; it climbs mountains and descends mines regardless alike of the rarefied air on the one and the condensed air in the other. The application of steam to deep mines is too well known to need notice here; but the mountain feats of the steam-engine are not so well known. The 'Journal of the Franklin Institute' stated, about two years ago, that a steam-boat had made its appearance on the waters of Lake Titacaca. Now this lake is situated among the Andes of Peru, at an elevation of 12,000 feet above the level of the sea, and close to the base of the mighty Nevada Sorata, the highest mountain in the world except a few peaks among the Himalaya. The nearest point of the lake is not more than 150 miles distant in a straight line from the Pacific; and it

may therefore be conceived how rapidly the ground must rise, and how difficult must be the transport of such a formidable affair as a steam-boat. It seems, however, to have been cleverly managed. The boat was built by Mr. G. Birkbeck, of New York; it is of miniature dimensions, being only 55 feet long by 12 feet broad; it has two high-pressure engines of 10-horse power each, and paddle-wheels 10 feet in diameter. The whole was fitted together at New York, every piece carefully marked, and then the whole pulled asunder again. It was conveyed to Lima by ship, and the pieces were carried up to Lake Titacaca on the backs of mules: the castings and fittings being so planned that no single piece should weigh more than 350 lbs. Arrived on the shores of the lake, it was put together, and commenced plying from end to end of the lake, a distance of 100 miles or more. The coast is well-timbered; and it seems very probable that this little steamer will be a pioneer of civilisation in those parts.

If there be any one class of machines respecting which there are more numerous inventions than any other, it is perhaps the steam-engine. Nothing can better illustrate the mechanical activity of our age than the newly patented and registered inventions concerning this subject; and it is worth a glance through the pages of the journals devoted to such subjects, to see the various aspects which these inventions present. We find that some such inventions relate to the mode of generating steam, by particular arrangements of the furnace and the boiler. Others (and these are very numerous) relate simply to the boiler itself; while a third group relate to the furnace and to the fuel-feeding apparatus. Then come those which have reference to safety-gauges, pressure-gauges, water-gauges, steam-governors, and other regulative mechanism. Still more numerous are those which relate to the general mode of action in the engine, and which give to it one or other of the several characters denoted by the words 'rotary,' 'oscillating,' 'trunk,' 'disc,' 'pendulous,' 'reciprocating,' 'expansive,' and so forth. Another class relates to the pistons or the stuffing-boxes; and another to the valves—from 'safety' to 'absolute safety,' from 'sliding' to 'conical.' Others are intended as means for remedying the evils of 'incrustation' and 'priming' in steam-boilers. The 'rotary' engines have been among the most numerous of recent novelties. They are intended to enable the steam to act *directly* in turning a wheel, without the intervention of piston-rods, cranks, beams, or other mechanism; and the inventors suppose that power would be thereby saved. On the other hand, there are opponents who stoutly deny that there is any gain of power by the use of such engines. Generally speaking, the experienced hands keep aloof from the 'rotary' theory, and leave it to younger experimenters.

But if the novelties in the steam-engine itself have been numerous, still more so have been the applications of steam-power in manufacturing operations. Where is now the department of industry in which the steam-engine does not labour? It pumps water, pumps chemicals, pumps air; it sets in action cutting, bruising, grinding, punching, hammering, slitting, forging, stamping, pressing, planing, grooving, and polishing machines; it lifts immense weights, and lowers weights to immense depths; it supplies steam for heating water, for melting solids, and for warming buildings; it rolls iron bars for railways, and iron plates for boilers, and lead for plumbers' work, and sheets of paper for mill-board, and bundles of steel blanks for needles, and engraved cylinders for calico printing, and lumps of dough for biscuits; it will gently crack a nut, or rudely crush a whole railway train; it will make a needle's eye, or will forge an anchor of ten thousand pounds' weight; it will

drain a small field, or will drain Haarlem Lake; it will plough land, thresh wheat, grind flour, make bread; it will spin cotton, make it into cloth, press the cloth into bales, transport the bales to ships, and transport the ships to every sea on the globe—in short, what the steam-engine *cannot* do, or aid in doing, is becoming more and more difficult to say.

To illustrate these various useful services by examples is quite beyond our present scope. Nearly every paper in this short series affords some such exemplifications. There are, however, such abundant modern proofs of the mighty agency of steam-power in respect to *transit*, that we cannot do better than dwell upon this matter—confining our notice to land-transit, steam-navigation having already occupied a little of our attention.

### Steam, as the great Transit-Agent.

Nothing can better illustrate the general character of steam-power as applied to railway locomotion, than a few statistics derived from Sir Francis Head's well-known article in the *Quarterly Review*, written in 1848, and referring to the London and North-Western Railway. For supplying the locomotives which start from London there are (or were in 1848, the number being now probably increased) 18 coke ovens at Camden Town, making 20 tons of coke per day; 30 tons more per day, required for the London service, being brought from the north. Coke is not put into the locomotives in a cold state, as it would require too long a time to heat the boiler; it is given in a white-hot state, from an oven applied to this especial service. To feed the boilers with pure water, an artesian well was dug to the depth of 140 feet at Camden Town, at a considerable expense; but the water, although good for all other purposes, contained too much soda for the delicate stomachs of the locomotives ("who would ever suspect *them* to be more delicate than our own?" asks Sir F. Head); and a supply had to be obtained from another source. A passenger locomotive usually takes in about a thousand gallons of cold water and about a ton of coke, which will carry it a distance of about forty miles. The large locomotives of the present day cost more than £2000 each; the tenders about £500. Each goods locomotive and tender, fully supplied with coke and water, may be taken to weigh 50 tons, and to be able to draw 600 tons at the rate of 12 miles an hour.

The Wolverton depôt forms an "immense hospital or 'Hôtel des Invalides' for the sick and wounded locomotive engines" of the southern part of this great Company's line. The locomotives themselves are purchased of various makers; but the repairs are executed by the Company at their own shops. There are immense engineering shops, provided with steam-worked planing, screw-cutting, turning, slotting, cutting, punching, polishing, and other machines; foundries for casting iron and brass; a smith's shop with twenty-four forges; steam-engines for pumping water; a hydraulic press for squeezing wheels upon their axles; and other works of great magnitude. At Crewe, which constitutes the depôt for the northern division, the works are on a scale of still greater magnitude; for they comprise all the requisites for building as well as repairing locomotives. These works turned out a new locomotive and tender every Monday morning during the year 1848; and when it is considered that a well-made locomotive comprises more than 5000 separate pieces of carefully-formed metal, it may be imagined how complete must be the organisation and the division of labour in such an establishment; for it is no rough smith's work which is in hand. Mr. Robert Stephenson has laid down a maxim, that "a locomotive engine must be put together as carefully as a watch."

Let us take, as examples of locomotives, a few which have lately been placed in a very favourable position for examination by all those interested in such matters. There is Mr. England's tiny locomotive for light trains; the total weight of the engine with the tender and water being only ten tons. There is Mr. Adams's miniature production, to which he gives the fanciful name of 'Ariel's Girdle,' and intended for similar purposes to that of Mr. England. There is Mr. Crampton's powerful and ponderous locomotive, 'Folkstone,' belonging to the South-Eastern Railway Company; and another by the same inventor, the 'Liverpool,' belonging to the London and North-Western Company, and intended for express speed on that line. The locomotive last named has cylinders of 18 inches' diameter, and 24 inches' stroke; the driving wheels are 8 feet in diameter; the locomotive weighs 32 tons, besides 4 tons of coke and water; the pressure of the steam is as high as 120 lbs. on the square inch; and the evaporation of the boiler when at full work is equal to no less than 1140 horse-power. In no other machines whatever is water converted into steam so rapidly as in a high-class locomotive. But the giant of the locomotive world is one of those adapted for the broad gauge; such an engine is capable of drawing a passenger train weighing 120 tons, at a speed of 60 miles an hour; the laden engine and tender weigh 52 tons; and at an ordinary mail speed the engine consumes about 20 lbs. of coke per mile.

Dr. Lardner adopts some ingenious arguments, or rather illustrations, to render familiar the extraordinary velocity with which our express trains move. The Great Western Express to Exeter travels at the rate of 43 miles an hour, including stoppages, or 51 miles an hour without including stoppages; to attain this rate, a speed of 60 miles an hour is adopted midway between some of the stations; and in certain experimental trips, 70 miles an hour have been reached. A speed of 70 miles an hour is about equivalent to 35 yards per second, or 35 yards between two beats of a common clock; all objects near the eye of a passenger travelling at this rate will pass by his eye in the thirty-fifth part of a second; and if 35 stakes were erected at the side of the road, a yard asunder, they would not be distinguishable one from another; if painted red, they would appear collectively as a continuous flash of red colour. If two trains with this speed passed each other, the relative velocity would be 70 yards per second; and if one of the trains were 70 yards long, it would flash by in a single second. Supposing the locomotive which draws such a train to have driving-wheels seven feet in diameter, these wheels will revolve five times in a second; the piston moves along the cylinder ten times in a second; the valve moves and the steam escapes ten times in a second. But as there are two cylinders, which act alternately, there are really twenty puffs or escapes of steam in a second. The locomotive can be heard to 'cough' when moving slowly, the cough being occasioned by the abrupt emission of waste steam up the chimney; but twenty coughs per second cannot be separated by the ear, their individuality becoming lost. Such a locomotive speed is equal to nearly one-fourth that of a cannon-ball; and the momentum of a whole train moving at such a speed would be nearly equivalent to the aggregate force of a number of cannon-balls equal to one-fourth the weight of the train:—that a 'smash' should follow a 'collision,' is no subject for marvel, if a train moving at such speed—or anything like such speed—should meet with any obstacle to its progress.

It can scarcely be necessary, in these days, to dwell at any considerable length on the important services rendered to society by the rapid travelling

which the steam-engine has placed within our power; but we will merely point to a few well-known facts, as so many clues which the reader may follow at his pleasure.

In the first place, then, cheap transport lowers the prices of all commodities in the market, and thereby stimulates production. The expense of transport, with insurance for risk and interest for sunk capital, forms a notable part of the price of every article; in some cases they constitute nearly the whole cost, and everything which increases the speed without increasing the cost of the transport, or decreases the cost without decreasing the speed, is so much clear gain to the community. How the steam-engine has wrought this benefit, in steam ships and on railways, the world well knows. Why are we able at the present time to purchase coals in London at a lower price than formerly? Is it not mainly by lessening the cost of transport? We can hardly realise in our own country, at the present day, the painful contrivances which alone can be adopted in countries ill supplied with transit-accommodation. Let us draw an example from the beautiful Dnieper Bridge, now being constructed by Mr. Vignolles at Kieff, in Russia. It is the largest suspension bridge in the world; and 3500 tons of iron-work intended for it have freighted sixteen ships from Liverpool to Odessa. At that point began the difficulties of transit. All this ponderous mass of iron-work had to be transported in rough carts, drawn by bullocks, from Odessa to Kieff, a distance of four hundred miles. The granite for the roadway, too, had to be brought from a distance of a hundred miles through a country destitute of roads.

The value of many animal and vegetable products depends greatly on their *quick* transmission to the hands of the consumer; such as farm produce, garden produce, dairy produce, and fish. The changes which the steam-engine have brought about in this respect are most remarkable. Live stock is killed in the grazing counties, and the dead meat is sent up (say) to London, sweet and good—thereby saving the expense of transporting the entire animal. Rabbits are sent to us from Ostend, ready skinned, and are sold to the consumers before there has been time for deterioration. Milk is now regularly brought to London every morning by railway, from open healthy districts where cows can be kept more cheaply than in London. Fresh fish now reach the busy inland towns, where they were before almost unknown. Many kinds of foreign fruit are now sold cheaply among us, simply because the Southampton steamers afford facilities for rapid transport. We know, also, that cheap and quick transport tends to equalise prices, and to bring about justice between the producer and the consumer. An article of growth or of natural produce may, at or near the place of its production, be not merely very low priced, but it may be not required at all; whereas it would be highly acceptable in a far distant region if quickly and cheaply transported thither.

All the above advantages relate to *commodities;* those relating to *passengers* have an interest peculiar to themselves. Every industrious man's time is equivalent to money; quick travelling, by economising time, economises wealth. Cheap and quick travelling is an important element in the industrial proceedings of the operative classes; for, if local circumstances create a demand for labour in a particular spot at a particular time, there may be an opening for operatives living in a district already (perhaps) overstocked. There is reason to believe that this transfer of labour from place to place is rapidly spreading in England, owing to the increased facilities for travelling. The wool-combers of Leicester go to Bradford in Yorkshire, in considerable

numbers, annually; the brisk demand for combed wool occurs at different periods in the year, at the two places; and cheap travelling has induced the men to adapt themselves to variation in the demand for labour. This makes a man practically a political economist, whether he be aware of it or not. The intellectual labourer, too, is in many respects a more efficient agent than in bygone times; the steam-engine has doubled his working power. Take the case of a lecturer. We can rarely take up the *Times* newspaper without meeting with advertisements announcing that a certain lecturer will lecture at (say) Liverpool on Monday, at Manchester on Tuesday, at Leeds on Wednesday, at Sheffield on Thursday, and so on; the distance between the towns being now no bar to the easy transference of his services from one to another on the morning of each day. Of that truly great wonder, a modern daily newspaper, it is scarcely necessary to speak in relation to the advantages of quick travelling. It is steam that tells us what Bombay is doing in a month after the events recorded; it is steam that gives us New York news in twelve days, and Paris news in twelve hours; it is steam that gives Edinburgh a London newspaper on the day of publication.

### Miscellanies of Steam.

There are many minor aspects in which steam and steam-power present themselves to our notice. Not the least curious is that often observable in Birmingham and other towns, where steam-power is *let* or *hired out*, by one person who has more than he requires, to another who wants a little, but cannot afford to buy a steam-engine. A belt or a cog-wheel will effect such a transfer.

The steam travelling crane, patented by Messrs. M'Nicholl and Vernon, of Liverpool, illustrates at once the *lifting* and *locomotive* application of steam-power. It is intended for lifting and removing heavy weights at the goods depôt of railways, in timber yards, in foundries and other manufactories, and for loading and discharging the cargoes of vessels. The crane, besides hoisting a load, may be moved backward and forward, and also to the right and left; and its activity is such that it will perform all three movements at once. The load is suspended from a kind of low four-wheeled carriage; this carriage moves along a platform; the platform itself moves in a transverse direction; and all these movements are communicated by a stationary steam-engine. There are cranes on this principle which command an area 266 feet long, by 53 wide; that is, the crane can lift a load from any part of this area, and deposit it at any other part, by a combination of its remarkable three-fold movements. It is said that one of these cranes, on one occasion, removed 13 logs of timber, containing 1050 cubic feet, and weighing 19½ tons, a distance of 100 feet (one log at a time), and piled them, in 27½ minutes, at an expense in wages of only *threepence;* the machine travelled 2600 feet (about half a mile), and made 26 stoppages in the time named, with an average load of 30 cwt. for half the distance. This illustration shows how nearly the machine is automatic, the steam-engine rendering manual aid almost unnecessary.

There have been recently many applications of steam in what is called a 'surcharged' state—that is, heated beyond the ordinary temperature—to manufacturing purposes. So long as steam remains in contact with the water which produced it, it can only have the temperature of that water; but if separated into another vessel, it may be heated to any degree that the vessel will bear, and it then possesses remarkable drying or baking qualities. M.

Violette read before the Academie des Sciences, a few years ago, a memoir on such applications. Steam is produced from an ordinary boiler, and thence passes through a coil of tube, where it is exposed to a higher heat; it is then sufficient to convert wood into charcoal, the charcoal having different degrees of blackness or carbonization, according to the temperature imparted to the steam. A command is obtained of a range of temperatures varying from 212° to nearly 1000° F.; and the steam thus heated is applied to many uses. Steam at 392° will bake bread and biscuit; it will extract wood-vinegar (pyroligneous acid); and is very efficient in seasoning timber. In this, as in many modern inventions, over-sanguine persons think they have found a new source of power. Highly-heated steam is more elastic, or exerts more pressure, than ordinary steam; and hence it has been urged that we may have almost any amount of power we please, by heating the steam sufficiently. But power must be given for power gained; fuel must be consumed for every increase of temperature in the steam; and it is not till after the quantity of this fuel is ascertained, together with that which originally produced the steam from the water, that the experimenters will be at all in a position to pronounce on the economical merits of this surcharged steam.

Steam is threatened by electricity, which bids fair to be a formidable competitor in some at least of our numerous engineering and manufacturing exploits; and coal itself is placed upon its trial by a new aspirant to public favour. Jumping to a conclusion from insufficient data, some journalists begin at once to read a funeral oration over coal—its occupation 's gone; the pits are to be deserted; the colliers are to take their swarthy persons elsewhere; the coal-owners are to be bankrupt; the coal-ships are to find employment in other kinds of traffic; the housemaid's jubilee is to commence by the absence of dust and ashes in the grates; her Majesty's fresh air is to be unpolluted by smoke and soot, and her Majesty's subjects are to reap the benefit thereof in their lungs and on their clean garments; and, as an agreeable winding up to the whole, a great economy of money and money's worth is to be effected. All this is to spring out of the employment of the *polytechnic fire*— a peculiar mode of applying gas to platinum, whereby the latter metal becomes heated to a red or a white heat, giving out much warmth without undergoing much combustion or waste. That a platinum fire may be produced, chemists well know; that it may be susceptible of advantageous application, is very probable; but a carefully prepared balance-sheet, a debtor and creditor account—founded, too, on long experience—will alone show what is the actual expense at which a given amount of heat can be thus produced. All this relates rather to coal than to the steam produced by coal; but *if* the project be sound, steam-power will be affected when coal is affected.

We have not yet arrived at the day when steam can be bottled up like water or gas, and carried from place to place; but we *have* reached that degree of skill by which steam can be made at one place and used at a place a furlong or more distant from it. Witness the Hyde Park arrangements, so instructive in this as in many other matters. Beyond the western extremity of the building was an engine-house, where steam was raised by a judicious arrangement of furnaces and boilers. This steam was conveyed underground to the 'machinery in motion' department, the east end of which must have been at least a sixth of a mile from the engine-house. If this steam had fallen in temperature, it would have become water—one cubic foot would suddenly have contracted its dimensions to one cubic inch, and the moving power would have been lost. How, then, was this disaster prevented? The pipes

which conveyed the steam from the five boilers were clothed with thick hair-felt, over which was placed a wrappering of patent canvas; thus was high-pressure steam conveyed to a distance never before attempted. The Cornish engineers, in the management of their mine-engines, are particularly sedulous in this method of giving a warm and closely-fitting garment to their steam pipes.

There are many recent contrivances and processes in which it is not easy to say whether steam-power, water-power, or air-power most prevails; two out of the three, or sometimes all three, being conjoined in them. They are examples in which two or three kinds of action are required at once, and it matters little which of them we take as the dominant power. Machines of a decided hydraulic action will receive attention in a later page; two or three examples of more mixed character here engage us.

Dr. Potts's method of making hollow piles, for bridges or other works in hydraulic engineering, is most noteworthy; for while it is not strictly steam-power, water-power, or air-power, it may comprise some of the elements of all three. In driving enormous wooden piles into the bed of a river, whether to support a superstructure or to form a coffer-dam, the mechanical power required is something quite astounding; and whether it is effected by the 'monkey' (a heavy rammer worked by many men pulling at many ropes), or by the more efficient 'steam-hammer,' it requires the erection of heavy apparatus in what may be difficult places. Hence Dr. Potts was induced to ask—"Can we not remove the soil from beneath the pile, instead of hammering away at the top?" The answer to this question led to the invention of the *hollow* pile, which has lately been much used by our great engineers. Suppose a pile to be about to be sunk in the sandy bed of a river. It is made hollow—a cast-iron cylinder, in fact, and is brought over the spot where it is to be fixed; the top is air-tight, except an opening for a tube leading to an air-pump above. When the air is drawn out of the cylinder, the sand and mud are *sucked up* also, and the cylinder descends into the vacancy thus occasioned in the bed of the river. In a railway bridge lately built over the Shannon, the piles or cylinders are ten feet in diameter; but they sank with extraordinary rapidity into the sandy soil, where they form the supports for the bridge. In the railway bridge now being constructed across the Wye at Chepstow, hollow piles have been sunk by this method under circumstances of great difficulty; the tide rises forty or fifty feet at that remarkable spot; and the hollow piles have enabled the engineer to surmount obstacles of a most embarrassing kind, by the combined aid of steam, water, and air.

A pressure of air produced by an air-pump has, in a remarkable way, been lately made to produce an explosion of gunpowder in mining operations. The agent is really chemical; but the air places this agent in a position to use its effective force. Supposing the gunpowder to be placed in its proper cleft in the rock, a gutta-percha syphon tube extends upwards from the gunpowder, and then descends again into a gutta-percha vessel containing sulphuric acid. Another gutta-percha tube, extending to any distance requisite for the safety of the operator, connects the vessel with an air-pump. A few grains of mingled white sugar and chloride of potash are placed upon the top of the charge of gunpowder, and then all is ready for operation. The air-pump is worked; a stream of air is forced through the long tube to the vessel; this air forces a little of the sulphuric acid through the syphon tube, and brings it into contact with the powdered sugar and chloride; a chemical action results,

which instantly produces an explosion of the gunpowder. There is something very ingenious in this arrangement, which is due to Mr. Taylor, of Dublin; he calls it a 'pneumatic battery,' and his object has been to produce a substitute for the more costly and delicate galvanic blasting in ordinary mining or quarrying. It is not difficult to see that air-power, water-power, or steam-power, may be made to produce analogous results by a fitting arrangement of mechanism; provided a few drops of sulphuric acid be made to fall upon the powdered mixture, the explosion will take place; and many little contrivances might bring about this result. The power—air, water, or steam—sets *something* in motion which causes contact between the acid and the powder; chemistry effects the rest.

Messrs. Morton's 'patent slip' is an instructive proof of the saving of expense which steam-power, applied in aid of ingenious hydraulic machinery, may effect to ship-owners. When a ship is out of repair, she must be removed wholly out of the water, as the only means for enabling the artificers to gain access to every part. It is for this purpose that *dry-docks* are constructed in our royal dockyards, at an enormous expense. Messrs. Morton, of Edinburgh, some years ago, constructed a 'slip,' or sloping platform, up which a ship can be drawn with much ease for purposes of repair. One of these slips can be constructed at one-eighth of the expense of a dry-dock of equal size. The Mediterranean ports have long been accustomed to the use of slips for repairing vessels; but the operation was so excessively slow and laborious that the hauling up of a ship of 500 tons is said to have involved an expense of 170*l.*; whereas Morton's slip has reduced the expense to a mere trifle. A steam-engine exerting one-horse power for every 100 tons, and acting upon a column of water in a tube, will draw a ship along or up the Morton slip at the rate of two feet and a half in a minute.

## Centrifugal Pumps and Hydraulic Presses.

But it is time now to turn our attention to the novelties and curiosities which modern ingenuity has presented to us in water-power and water-processes of many kinds. Abundant proofs have recently been afforded that steam agency has not yet eclipsed hydraulic agency in engineering and manufacturing operations.

Great attention has lately been paid to those curious centrifugal pumps which raise water by the revolution, in that water, of a small wheel, producing a result very much greater than would by most persons be expected. These centrifugal pumps, whether we take Mr. Appold's or Mr. Bessemer's form of the apparatus, are exceedingly beautiful in principle. It may appear a descent from a great result to a very humble one, to appeal to the 'trundling' of a mop as an illustration of this centrifugal action; but it is really one of the best that can be adopted. The wet mop, set into rapid rotation, gives a centrifugal tendency to the water entangled among the fibres, and this water flies off with considerable force. If the mop, by other rather than manual power, were made to rotate yet more rapidly, the water would dart off violently. If the handle of the mop were a hollow tube connected with a water tank, if the mop-head were a flat circular box, and if the porous fibres were represented by channels proceeding from the centre to orifices at the circumference of the box, we should have a rude representation of Mr. Bessemer's centrifugal pump. Water gains admission to the centre of a rapidly-revolving box; channels convey the water from the centre towards the circumference; and

the water is driven thence up a vertical tube left open for its reception; the height to which, or the force with which, the water is so driven being wholly dependent on the centrifugal force which drives it from the centre to the circumference of the box. In Bessemer's machine the axis of the box, disc, or drum is vertical; in Appold's it is horizontal; but the principle of action is nearly the same in the two cases. As compared with ordinary pumps, these centrifugal machines are best adapted to the movement of a great body of water to a small height, whereas valve-pumps are better fitted for forcing water to a great height rather than in large quantity.

Mr. Appold's pump raises a remarkably large body of water with a comparatively small power. With a hollow cylinder, 12 inches in diameter by 3 inches deep, to which a rotation of 800 times in a minute is given by a steam-engine, this little machine can raise 1800 gallons of water per minute to a height of 10 feet. The cylinder itself holds very little more than one gallon; and yet such is the force generated by the rapidity of revolution, that eighteen hundred gallons pass through the cylinder in the short space of a minute. On one occasion (to test the simplicity of the machine) half a gallon of walnuts were put into the cylinder; they were driven out without injury to themselves or to the cylinder—there being no valves of any kind in the latter. A cylinder one foot in diameter has been made to drive water to a height of nearly seventy feet. In November, 1851, one of these pumps was set to work to assist in draining Whittlesea Mere. The cylinder was four feet and a half in diameter, and was immersed in one of the channels or cuts by which the Bedford Level is intersected. A steam-engine was erected on the spot, and steam-power applied to the turning of the cylinder. Up rose the water, and poured into a channel prepared for it, in immense volume; if raised just sufficiently to escape from its former channel, it rose in greater quantity than if forced up to a greater height. No less than sixteen thousand gallons of water per minute were raised by this means, all of which passed through the cylinder of the machine. These are notable results. One of Mr. Bessemer's pumps, with a cylinder nine feet in diameter, has raised as much as two hundred tons of water in a minute by the aid of a thirty-horse power engine.

Something approaching to the centrifugal action seems to be involved in Messrs. Marsden's new 'washing, wringing, and mangling machine'—one among many proofs of the successful search for mechanical novelties in our day. The name sounds oddly, it is true; but the manual operations to which the machine relates are really of a laborious kind; and there seems no reason for withholding mechanical aid therefrom, other than the timid fear of disturbing the demand for labour in that particular occupation. This machine, we are told by the inventors, "exhibits much novelty in the fitting-up and action of the cylinder, including oscillating frames, springs, &c., and resembles the action of the human hand." The machine occupies little room, can be easily removed, and will 'wash and wring' four blankets in ten minutes; it can be worked with ease by a girl; it saves time, soap, and labour; and infected linen can be washed by it safely. When constructed of larger size, it can readily be worked by steam-power.

But the *drying* process, by this centrifugal agency, is of very wide application. Bleachers, dyers, calico printers, all use it. The wet mass of cloth or yarn is put into a hollow cylinder; this cylinder is made to revolve from one to two thousand times in a minute; the moisture is driven from the cloth with great violence; openings are left to afford an exit for this water into an outer vessel; and in a few seconds the cloth is nearly dry. Nothing but

actually witnessing the process can convey an adequate idea of the rapidity of this drying process. In some of the baths and washhouses now established, machines of this kind are employed to supersede the hard necessity of 'wringing' the wet linen—a great boon to the poor women who avail themselves of these advantages.

A curious application of centrifugal force is in the separation of crystallized sugar from molasses—quite a modern process. When 'lump' or 'loaf' sugar has been bleached and purified and crystallised, there still remains mixed up with the crystals a yellowish brown viscid liquid, which will *not* crystallise; and this must be separated before the beautifully white sugar will be fit for the market. Under the old method, the sugar-loaf mould was turned upside down, and liquid was made to trickle slowly through the sweet, spongy mass; the liquid was either water, or alcohol, or a solution of sugar in water; and the molasses, washed out by these means, escaped by a hole at the small end of the sugar mould. But it has recently been found that the same remarkable centrifugal action which drives out moisture from cloth will do the same in respect to a mass of wet sugar. The crystallised or granulated sugar, steeped in a murky bath of molasses, is made still more moist with water; about half a hundredweight is put into a sieve-like circular vessel; this vessel is made to rotate 1000 or 1200 times in a minute; and the whole of the molasses and water are driven violently and quickly out of the mass, leaving the sugar in a nearly dry and pure state. M. Van Goethem, a Belgian sugar refiner, has invented a surprising machine, in which fifty sugar-loaves are ranged radially in a kind of horizontal wheel, and then the whole made to revolve with a speed of eight hundred revolutions in a minute. The proper liquid is applied by a beautiful contrivance; and in about twenty minutes the whole of the fifty loaves of sugar are found to be not only freed from molasses, but rendered almost completely dry. Many days would be required to effect this by the old method.

Another, and a very pleasing application of this force, is that adopted by Mr. Masters in making ice for confectionery purposes. One apparatus, of a large size, is capable of freezing upwards of one hundred quarts of liquid into ice in a quarter of an hour—six different kinds of ice being producible in the one machine, at one time. Not only can the machine make dessert ices, such as raspberry ice, lemon ice, &c., but it can as readily produce large hollow cylindrical blocks of pure ice, into the hollow of which may be placed decanters of water or bottles of wine to be cooled. Some of these ice-cylinders are made in ornamental forms; and when placed on a properly-constructed stand, they diffuse an agreeable coolness in a heated room. This ice-making process, however, is in part chemical. Many salts and acids, when mixed, produce an intense degree of cold in the surrounding space. Mr. Masters has discovered a mixture which produces this reduction of temperature to a very extraordinary degree. The confectionery or liquid which is converted into ice is placed in a vessel of white metal, around which is the space filled with the freezing mixture; and around this again is another space filled with pure spring water. Of these three cylinders, the innermost is made to revolve with great rapidity, by which the freezing mixture acts quickly on the cream or liquor, and ices it; while at the same time the spring water is converted into a cylinder of beautiful ice. The centrifugal action of the inner cylinder drives the confection forcibly against the sides, where it can be more readily acted upon by the freezing mixture outside that cylinder.

The applications of these centrifugal machines in manufactures are now so

numerous and varied, that we may reasonably expect to see many interesting results presented by them.

Another class of hydraulic machines, which has lately been brought to a high degree of efficiency, is the hydraulic press, or—from the name of its ingenious inventor—better known as the Bramah press. For producing a slow but irresistible pressure, few forms of machine have ever equalled this, whether moved by steam or by any other source of power.

Never before the raising of the Britannia Bridge were there employed such ponderous masses of iron in the construction of a hydraulic press; for never before was there such a daring enterprise in which such a press was required. Two wrought-iron girders, weighing 12 tons each; two cast-iron beams of 5 tons each; a 'jacket' of cast and wrought iron, around the cylinder, weighing 8 tons; the cast-iron cylinder itself, of 15 tons; the ram or piston to work within the cylinder, of nearly 4 tons; the cast-iron cross-head of 13 tons; besides the clamps, chains, guide-rods, valves, and other parts of the mechanism—such were the weights given to the parts of a machine intended for only one single operation, the raising of the tubular bridge. A special goods train was required to bring this press to London for exhibition, and sixty horses to convey it from Euston Square to Hyde Park.

It forms no part of the present subject to treat of the casting and manufacture of these huge masses: but it is worthy of being borne in recollection that the cylinder was 9 feet high, $3\frac{1}{2}$ feet in external diameter, and formed with 9 inches' thickness of metal. Although in its finished state it weighed only 15 tons, yet $22\frac{1}{2}$ tons (more than 50,000 lbs.) of molten iron were required for the casting; this was, we believe, nearly if not quite the largest single casting ever executed. The mass of iron was red hot three days after the casting; it was removed from the pit on the seventh day, and was too hot even on the tenth day to be approached except by those accustomed to the fierce glowing masses of an iron-work.

To show how skilfully our modern engineers now adapt their materials to the particular kind of pressure which they have to bear, we may mention that two upright 'sandwich' girders, which had to bear a weight of 1177 tons, were formed simply of six parallel upright ranges of boiler-plate, $\frac{5}{16}$ths of an inch thick, interlayered (or inter-sandwiched, we might perhaps say) with planks of American elm 2 inches thick.

The greatest weight actually lifted by this extraordinary press at any one time was 1144 tons (more than $2\frac{1}{2}$ million lbs.); which was effected in lifts or distances of 6 feet each, requiring a little over half an hour for each lift. Now what, the reader may ask, was the body of water which, by pressure, lifted this unparalleled weight—unparalleled by anything which the ingenuity of man had before achieved? It was simply $81\frac{1}{2}$ gallons, about a hogshead and a half! A hogshead and a half of water flowed into the cylinder from a small pipe; it had not room in the cylinder below the ram, and it therefore thrust up the ram to make room; and in so thrusting up the ram it forced up at the same time the weight which pressed on the ram, viz., the chains supporting one of the long tubes for the bridge. Even one man working the pump has raised 22 tons. Never before did eighty gallons of water do such work. If we trace the operation further, we shall of course find that the *real* source of power exhibited itself at an earlier stage; it was the steam-engine which forced the water; but still it remains true that the remarkable incompressible quality of water was the immediate instrument employed. The water was forced from the pipe into the cylinder, by the steam-engine,

with a pressure of nearly four tons per square inch; and this pressure was transferred to the whole under surface of the ram. Mr. Edwin Clark, in his very interesting account of the Britannia Bridge, gives some startling illustrations to show the real amount of this power; he shows that the power with which the water was forced and continued during the whole elevation of the tube, would have been sufficient to drive it up a pipe to a greater height than any mountain on the globe, supposing that such a pipe could be formed and maintained; or that such a power, if made to work an ordinary pendulum clock, would set it going for 240,000 years! Such illustrations may appear extravagant, and extravagant they would be if meant to imply any really practicable result; but they are intelligible and true if taken simply as estimates of the *quantity of power* produced and exerted. The hogshead and a half of water is made virtually to contain the enormous mechanical power above adverted to, by the state of compression which it is forced by the steam-engine to assume.

Among the recent productions exhibiting the amazing power of the hydraulic press is one manufactured and worked by Messrs. Hick, of Bolton. It consists of a press with four cylinders, having an aggregate power of 2500 tons' pressure. Two objects are attained by the use of four cylinders; the metal castings are much less ponderous collectively, than one would be having equal power; and there are facilities for using either two or four at a time, according to the amount of power required. Many persons may have recently seen the model of this hydraulic press, accompanied by witnesses to testify to the wondrous power of the real press itself. These witnesses were in the form of circular pieces of iron, cut out of thick slabs *while cold*, by the pressure of the machine; and it was difficult to bring the mind to the belief that such work *could* be done by such means. The pieces were about eight inches in diameter; one was an inch and a half in thickness, and had been cut out of a slab of iron by a punch pressed with a force of 700 tons; another, 2 inches thick, required a force of 950 tons; a third, 2½ inches, required 1253 tons; a fourth, 3 inches, needed 1600 tons; while the giant of the whole, 3½ inches thick, had refused to yield to a less pressing force than 2050 tons—more than four millions of pounds. Such was the work which a small pump enabled the hydraulic press to perform.

## Water Supply; Projects and Capabilities.

There are many curious matters arising out of the supply of water to towns. Whether a steam-engine raises water from a river (as at old London Bridge), or an aqueduct brings water from a distance (as the Croton Aqueduct at New York), or an artesian well draws water from a great depth (as at Southampton), the engineering arrangements involve many highly-interesting points. We shall not, however, dwell upon the well-known characteristics of this subject, but shall glance at a few aspects of the 'water question' at the present day.

This question of water supply for a monster city of two millions of inhabitants is entangled by a greater number of conditions than would at first seem probable. One is, that there ought to be little or no carbonate of lime in the water. M. Soyer tells us that 'hard' water (water containing lime) turns boiled vegetables to a yellowish colour, and that it does not well open the pores of boiled meat; every housewife knows that it is unfitted for making tea and other infusions, and for washing clothes. The Board of Health

Report on this subject states that "more money is expended in washing clothes than in the manufacture of the fabric, or of the clothes themselves;" and that, in London, "before a shirt is worn out, five times as much money as it originally cost will have been expended on it in washing." Hard water requires more fuel, too, to raise it to boiling heat. Professor Clark has proposed that, when a gallon of water contains one grain of carbonate of lime, it shall be said to have *one degree of hardness*; so that different specimens of water can be easily compared in this respect. In the process of 'softening' hard water, to fit it for domestic purposes, 2 ounces of hard soap are required in 100 gallons of water for every degree of hardness; consequently when the water is very hard the consumption of soap is seriously large. Bathing is much more effective and pleasant in soft than in hard water. The great porter brewers go to a vast expense in obtaining soft water. The Board of Health chemists found that the water from surface drainage in various parts of England averages about 5 degress of hardness, from rivers and brooks 13 degrees, and from wells and springs 26 degrees; the Thames, the New River, and other streams which supply London, have from 13 to 16 degrees. It is said that *twenty-six tons* of lime are mixed up with the *daily* supply of water for the metropolis.

The Board of Health, whose duty it was to investigate the subject of the supply of water to London, enumerate the following as the qualities which such water should possess:—softness, or freedom from lime; freedom from animal and vegetable matter; aëration by a pure atmosphere; freedom from earthy and mineral matter; medium temperature; limpidity or clearness; absence of special flavour or taste. When it is recollected that the Board had to take all these data (or rather desiderata) into account, as well as those relating to the geological and to the commercial aspects of the inquiry, it will be evident that the task was a somewhat formidable one. Of the seven qualities required in the water, the Thames is pronounced to be very deficient, in the part near London. It is also said by the Board that the Thames within reasonable distance of London, and all rivers flowing into the Thames within that limit, though better than Thames water *at* London, are yet lamentably deficient in the requisite qualities; and it is recommended in plain terms that "the water of the Thames, the Lea, the New River, the Colne, and the Wandle, as well as that of the other tributaries and sources, of the same degrees of hardness, should be as early as practicable abandoned."

*River-water* being thus 'thrown overboard' by the Commissioners, they tried *well-water;* but here, also, they were dissatisfied. Such water has many mineral impurities; but a greater obstacle is, the limit in the supposed available quantity. There are one or two facts which throw a curious light on this deficiency of supply. "The great porter brewers have arranged among themselves to brew respectively on different days, so as to equalise the demands on the water-bed; it is farther stated that water is higher in the wells on Mondays than on any other days, by reason of there being no brewing on the Sunday. This difference in the level of the water-bed is felt as far from town as Tottenham."

What is to be done, then? If river-water be bad, and well-water deficient, what shall be our resource? The *Lancashire plan*, say the Commissioners, a plan by which surface land-drainage is obtained. The nearer to the actual rain-fall the water is collected, the freer it will be from adventitious impurities; and this principle has been made the basis of operations in many parts of Lancashire. The engineers "take some elevated ground, generally sterile

moorland or sandy heath; and run a catch-water trench or conduit round the hill, midway, or as high up as may be convenient for the sake of fall, regard being had to the space of the gathering-ground. An embankment is thrown across some natural gorge at the nearest point at which a reservoir may be formed without the expense of excavation. Into this the rain-water is let and stored." The sad calamity at the Holmfirth reservoir resulted from the neglected state of an embankment of this kind. If the drains and channels can be judiciously made through a sandy stratum, the water may be obtained very pellucid and pure.

Such being the case, then, the Commissioners are looking around them to find a water supply of this kind. Some have had an eye to Richmond Park, the gravelly loam of which affords beautiful water. Others have been examining the district between Bagshot and Woking. "Farnham has for some time," we are told, "been supplied with soft water by the drainage of less than two acres of common land; the water is clear and limpid at all times of the year; and there are many square miles of similar country near, almost wholly useless for any agricultural purposes." The Commissioners are of opinion that an abundant supply for the metropolis, of very beautiful soft water, may be obtained from this district. One difficulty is the paucity of any natural hollows into which the water could flow as reservoirs. Estimates have been made that the construction of the enormous *covered* reservoirs at Bagshot to contain the water for two millions of souls, and of the covered channels from thence to London, would not be less than one million sterling; but it is at the same time urged that "two years' saving from the use of the purer water would fully repay this portion of the outlay."

There is a proposition of considerable interest and importance connected with the future water supply of London. What supply may ultimately be adopted no one can yet tell; whether the six or eight companies may continue their own plans, or river water be drawn from Watford or elsewhere, or artesian wells be sunk, or surface drainage be brought from Bagshot. But, supposing an ample supply be obtainable, it is proposed in many quarters that the water should always be at *high pressure*, by powerful steam-engine arrangements at the reservoirs; at present water is 'turned on' and 'turned off' at certain days and hours; but the 'continuous supply,' now adopted in a few towns in the north, is found to have many advantages, and a high pressure is necessary to fulfil the conditions of this continuous supply. Supposing, then, the water-pipes of a house to be always full of water in a state of pressure, ready to rush forward when any opening offers, should we not have a source of mechanical power—a working agent—always at hand? Pressure of water will move machinery as effectively as pressure of steam; and hence has arisen the question of combining water-supply with power-supply.

The Board of Health, in the recent Report on the Water of Towns, touches on this matter in the following words:—"At present many trades employ very small steam-engines for purposes that may, almost as cheaply, be accomplished by hand; for instance, coffee-grinding. There are many purposes for which steam might be substituted for manual power with advantage, were it not for the cost of skilled labour required to attend to it, and the expense and trouble of keeping up the steam when the power is not wanted. If some hydraulic engines (such as the tourbine or the centrifugal pump) were employed and worked by water from the pipes—which could be set to work and stopped in an instant, which consumes no power except when at

work, which requires no skilful mechanic to work it, and is quite free from risk from fire or explosion—there is no doubt that numerous applications of such power would be introduced which are as yet scarcely thought of. It would be easy to work cranes and hoists for raising or lowering goods or persons in warehouses, where the occasions for their use are not sufficiently numerous to render a steam-engine economical. Such an instrument would work presses in the smaller printing-offices, where it is not worth while having a steam-engine. For many purposes a simple hydraulic press, with a large cylinder acted upon by the direct pressure from the pipes, would be sufficient for packing. In others, Bramah presses might be worked by the hydraulic machine. Turners might work their lathes, and smiths their bellows, by water-power; chaff might be cut, and oats and beans crushed, by the same means—in fact, it is impossible to mention all the various uses to which it might be applied if water were supplied constantly and at high pressure."

### Water and Water-Power:—Miscellaneous Scraps.

The remainder of this sheet may conveniently be occupied by a few miscellaneous matters arising out of, or connected with, the subject before us.

A word or two, then, upon *filters*. Mr. Forster's *pressure filter* is a very pretty application of a well-known hydraulic principle. There are two hollow hemispheres, exactly fitting one to the other, and both formed of a peculiar kind of porous sandstone; and these are enclosed in a larger sphere formed of metal, glass, or earthenware. The water which is to be filtered is made to flow into the open space between the two globes, through a pipe arranged for that purpose. The water, with the ordinary pressure which it has from the common street supply, has sufficient momentum to force itself through the porous substance into the inner globe; but the impurities cannot so find a path for themselves—they are left behind in the space between the globes. The filtered water has an outlet by a tap which communicates with the inner globe. Other filters, of a more familiar kind, act simply by the descent of water by its own weight through a porous stratum of sand or charcoal or some other finely-divided substance.

A word or two also concerning *fire-engines*. These engines occupy a peculiar place among hydraulic mechanism, in nearly the whole of the manufacture (for this country) being in the hands of two or three firms. The largest of these engines require twenty-four men to work them, twelve on each side. Small engines for private mansions, and garden engines, can often be worked by one person. There has been recently amongst us a magnificent fire-engine, sent from Canada—much to the surprise of John Bull, who was not aware that his Canadian brethren had reached so high a pitch of house-on-fire civilisation; it required forty men to work it, and had many peculiarities of construction. The French fire-engines are smaller, being worked by six or eight men.

There is an American fire-engine, recently invented by Mr. Lay, of Philadelphia, which has a clever contrivance for economising time as much as possible. The machine itself is a steam fire-engine, worked by steam-power instead of by men; and is so far analogous to one invented in London about twenty years ago by Messrs. Braithwaite and Ericsson: but it has, in addition, another working power to be made available while it is being heated and the steam generated. Carbonic acid gas can, nowadays, be made to

drive machinery, and it is only kept in the background because steam-power can be obtained and worked cheaper. The engine is kept ready, with water in the boiler and fuel in the fire-box, to generate steam in ten minutes. On an alarm of fire being given, the fuel is kindled; and at the same time a supply of carbonic acid gas is placed in a suitable apparatus sufficient to propel the instrument to the spot required, and begin working; the steam then takes up the duty, and finishes the work to be done. By a very curious mechanical arrangement, the hind wheels are lifted from the ground when the engine is stationary, and made to act as fly-wheels. The engine is said to be able to force three or four hundred gallons of water per minute upon the burning materials. This ingenious machine, it will be perceived, illustrates at once the action of a gas-engine, a steam-engine, and a force-pump.

Different in action from the fire-engine, from the centrifugal pump, from the hydraulic press, and from the common pump and the common water-wheel, is the *hydraulic ram*, which produces power in a way somewhat remarkable. It was originally invented in France by Montgolfier, who obtained a widely popular notoriety for his feats in connection with ballooning; he patented the invention somewhat above half a century ago; and the English patent has passed into the hands of Messrs. Easton and Amos, our distinguished hydraulic engineers. The hydraulic ram, as compared with the various kinds of pumps, is best adapted for raising moderate quantities of water, for household, or workshop, or farming purposes. It consists of an air vessel, provided with two water-valves and one air-valve; and it is the curious alternation of action between these valves that causes a column of water to be raised. Although it is difficult to describe this action in words, it is very instructive to those who will study it. It requires no steam-engine, no crank, no wheel-work to set it in action—a cistern merely 'running over' would supply all the force necessary. A pipe would convey the water down from the top of the cistern to a lower level, where it would enter the ram; and by the mere momentum acquired by the water in making this descent a force is created, which force is by the action of the valves made to drive a stream of water to a considerable height through a vertical tube.

Mr. Armstrong, of Newcastle, has adopted a remarkable mode of applying water-power to machinery; an apparatus which rather resembles the steam-engine than a pump, as far as concerns the movement of a piston. In these 'water-pressure engines' the motion is caused by water, under a great head or pressure, acting upon a piston in a cylinder; and various machines are attached to the piston rod, according to the kind of movement required to be produced, or the work to be done. One of these machines is a crane for lifting heavy goods at a quay or wharf; another is a coal lift, for loading or unloading ships; a third is a corn-lift, for use in granaries and warehouses; they are, in fact, all more or less of the crane-kind. Many of these machines are in use in the West India Docks. At Newcastle, Mr. Armstrong has devised the means of working the crane by the pressure of water in the common water-pipes of the town; the crane is on the quay; but the mechanism for working it is underground. The chief appendage visible, besides the crane itself, is a sort of dial-plate, with handles for guiding all the movements of the machine, such as raising, lowering, stopping, &c.; these handles act upon valves which regulate the water-pressure beneath, so that the movements produced can be proportioned to the work required to be done. We may yet see water-power, in our streets and houses, working bravely for us.

The injecting apparatus now employed in the preservation of timber pre-

sents a very instructive combination of steam-pressure, water-pressure, and air-pressure. We have adverted to this when treating of WOOD.

Some of our modern contrivances have relation to the quality of the water itself rather than to mechanical movements given to it, and to these our concluding page may not unfittingly be devoted. The conversion of salt water into fresh, for use on board ship, would be one of the most valuable means of economising space ever adopted, on account of the necessity which, under ordinary circumstances, exists for taking such a large bulk of fresh water. The project of this conversion is an old problem; but it does not appear that the Government or the ship-owners have yet done much in the way of adopting any of the recent inventions. Seamen are proverbially slow to change; and it may be that they have a prejudice against the use of freshened sea-water; or it may be that the coals necessary to heat the water for distillation may be considered a burthen nearly as cumbrous as the casks of fresh water. Nevertheless there is something doing in this way, for we occasionally hear of the employment of Grant's 'Cooking Galley' for this purpose. The following is one such announcement made in the *Times* between two and three years ago:—"During the present month three of Her Majesty's ships—the *Arrogant*, the *Plumper*, and the *Reynard*—have sailed from Portsmouth, furnished with the Government distilling and cooking galley, constructed by Mr. Grant. Other galleys of the same kind are also in course of manufacture for the largest class of vessels. The *Dauntless*, 1496 tons; the *Termagant*, 1556 tons; and the *Encounter*, 906 tons—all new ships, on the screw principle—are ordered to have first-class machines of the above description. By the improvements made since the introduction of the galleys into the naval service, the quantity of fresh water obtained by the distillation of salt water, during the period it is required to keep the fires alight in the galley for purposes of cooking, will on the average supply each individual on board the vessels with one gallon of distilled water every day. The latter kind of water continues to be preferred, for drinking and culinary purposes, to water usually supplied to ships; it passes immediately from the condenser into the water-tanks at the same temperature as the surrounding ocean. In these tanks it becomes perfectly aërated, losing altogether the vapid flavour common to all distilled water in the course of a few hours, without the aid of chemical preparation or mechanical arrangement, by the simple fact of the action imparted to the fluid by the motion of the ship when at sea." This account is so laudatory, that we may wonder why any ships are without such apparatus. The heat of the cooking-fires effects all the distilling. The difficulty in all these contrivances has been in preventing the distilled water from retaining its tasteless insipid quality: it has none of the briskness of spring water. In March, 1852, the *Simoom*, iron troop steam-ship, was provided with a cooking galley to distil fresh water from salt water at the rate of one gallon per minute.